NOAA'S National Weather Service

Elite Concepts of
Severe Storm Spotting

2011 – Rusty Kapela
Milwaukee/Sullivan
www.weather.gov/mkx

Elite Spotter Outline

- **Review**
  - *Types of T'storms*
- **Tornadic Supercell**
  - *Classic, LP & HP Supercell*
  - *Wedge vs Rope Tornado*
  - *Rain wrapped Tornadoes*
- **Mesocyclone**
- **RFD & Tornadogenesis**

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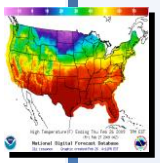

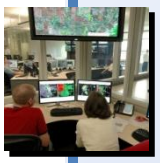

Types of Thunderstorms

Single Cell	Multicell Cluster	Multicell Line	Supercell
Weak updraft (non-severe or severe)	**Moderate updraft (non-severe or severe)**	**Moderate updraft (non-severe or severe)**	**Intense updraft (Always severe)** **Mesocyclone - Rotating updraft**
Slight threat	***Moderate threat***	***Moderate threat***	***High threat***
			

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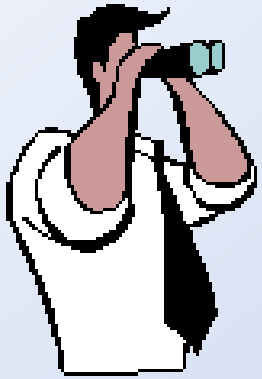
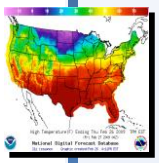
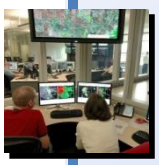
Cyclic Supercell







Cyclic Supercell

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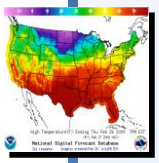
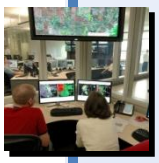
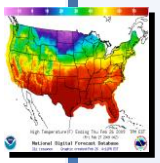
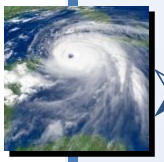


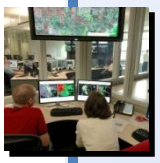


Cyclic Supercell

- The original updraft tower and associated tornado eventually become “occluded” as they are cut off from their warm, moist air supply (tornado falls apart – spins down).
- Meanwhile, a new updraft tower and mesocyclone develop downstream to the east-northeast (assuming storm moving to the northeast), and eventually a new tornado spins up.
- Process can repeat itself 3 to 6 times







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Cyclic Tornadogenesis

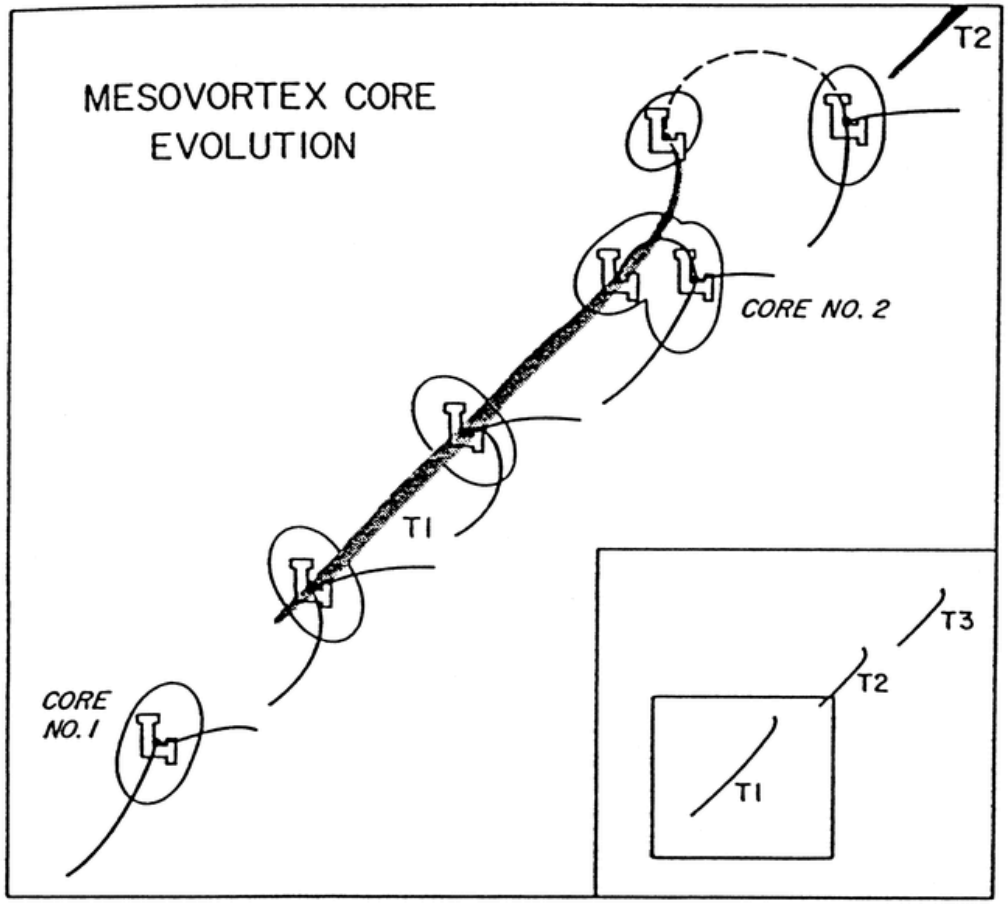

Fig. 1. Conceptual model of mesocyclone core evolution as proposed by Burgess et al. (1982). Dark shaded lines indicate tornado tracks, and thin lines represent low-level wind discontinuities (gust front).

Burgess et al. 1982

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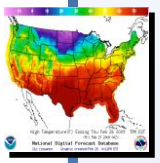
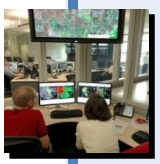
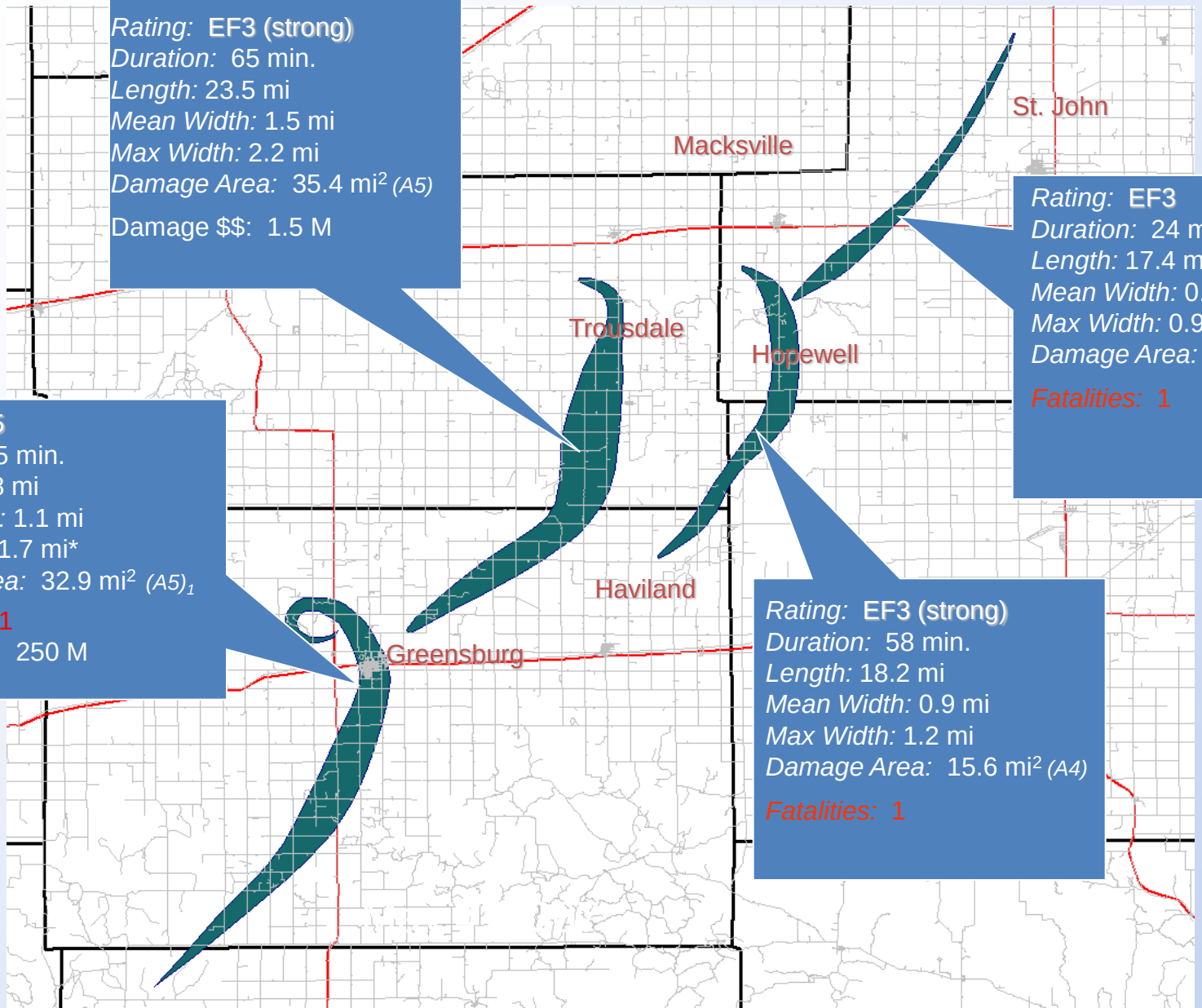




Greensburg Cyclic Supercell

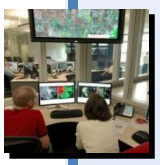


Rating: EF3 (strong)
Duration: 65 min.
Length: 23.5 mi
Mean Width: 1.5 mi
Max Width: 2.2 mi
Damage Area: 35.4 mi^2 *(A5)*
Damage $$: 1.5 M

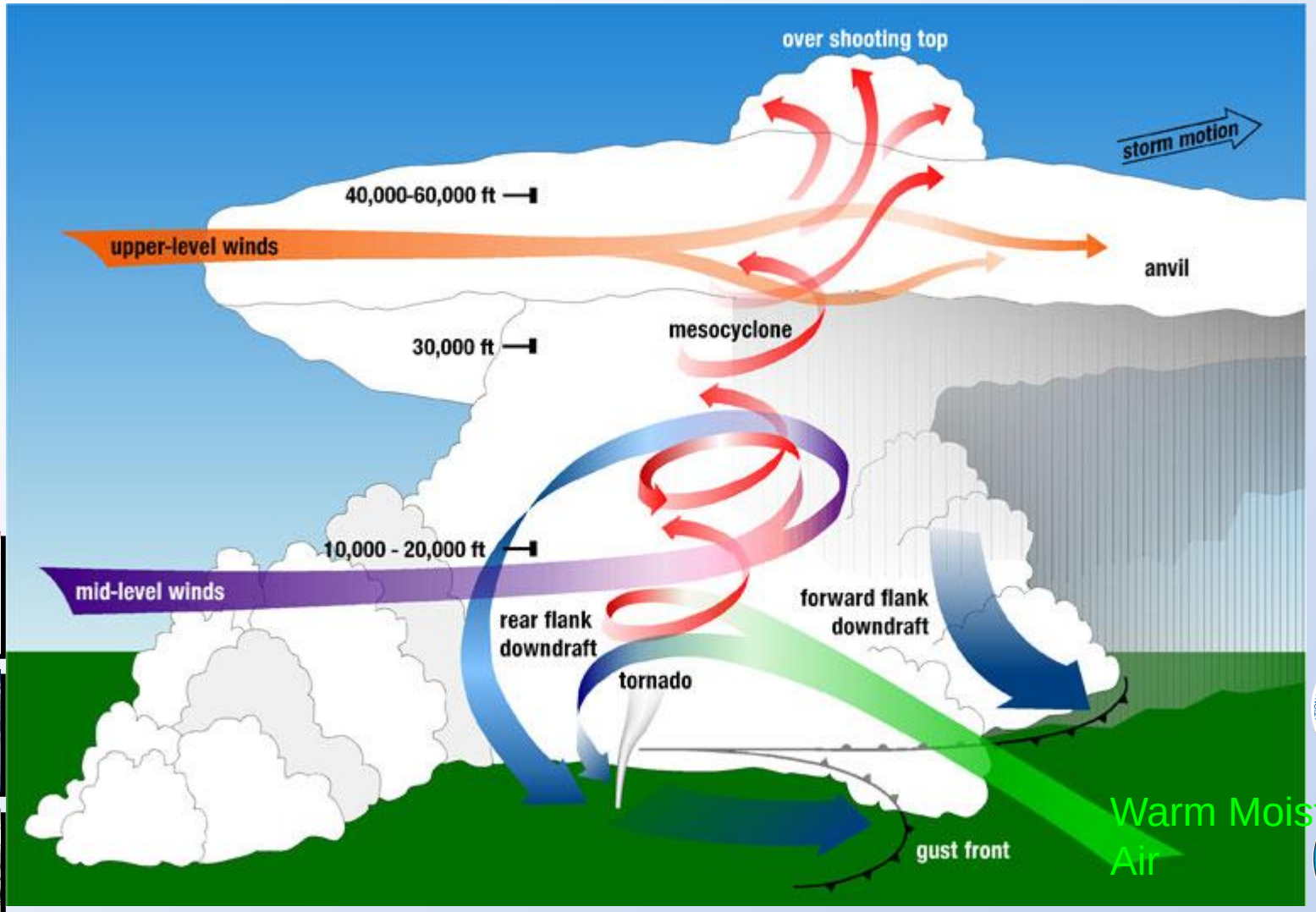
Rating: EF3
Duration: 24 min.
Length: 17.4 mi
Mean Width: 0.6 mi
Max Width: 0.9 mi
Damage Area: 9.7 mi^2 *(A4)*
Fatalities: 1

Rating: EF5
Duration: 65 min.
Length: 28.8 mi
Mean Width: 1.1 mi
Max Width: 1.7 mi*
Damage Area: 32.9 mi^2 *(A5)$_1$*
Fatalities: 11
Damage $$: 250 M

Rating: EF3 (strong)
Duration: 58 min.
Length: 18.2 mi
Mean Width: 0.9 mi
Max Width: 1.2 mi
Damage Area: 15.6 mi^2 *(A4)*
Fatalities: 1



NSSL – Supercell Model



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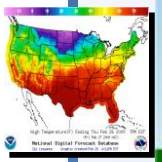
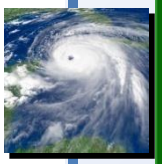
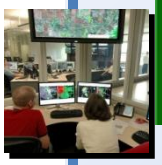
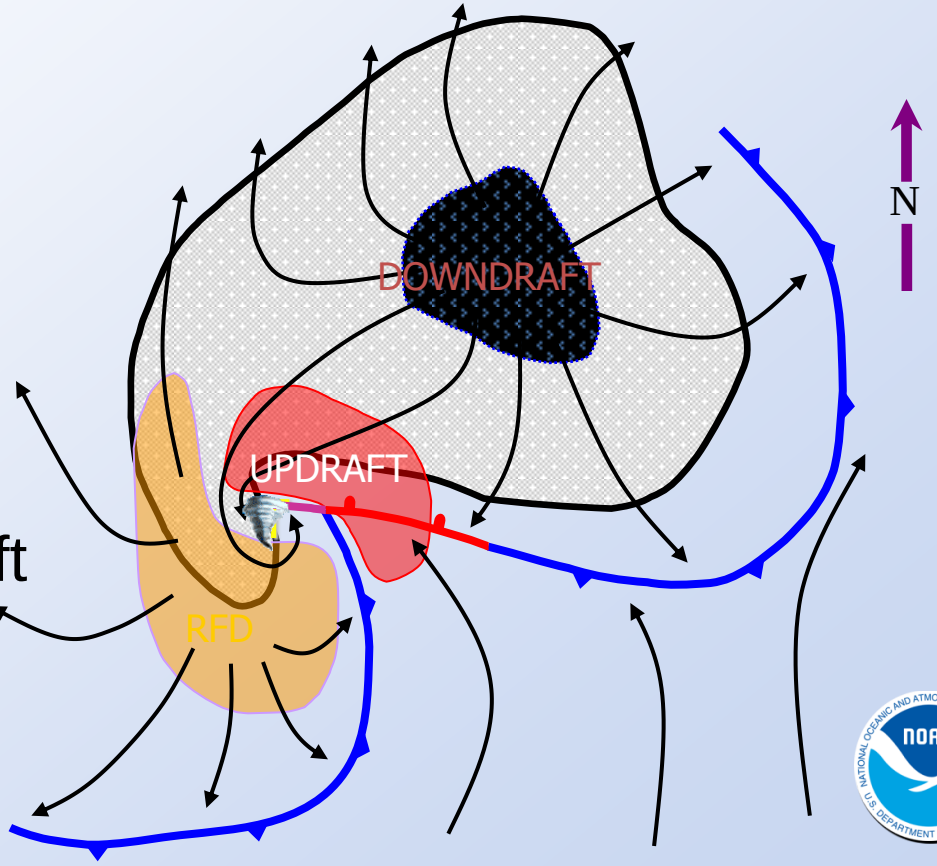






Rear Flank Downdraft

- Crucial to tornado development
- Downdraft on backside of updraft tower
- Wraps around updraft to tighten low-level circulation



(Top view)

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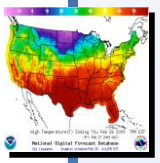
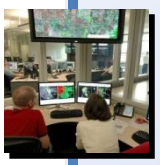
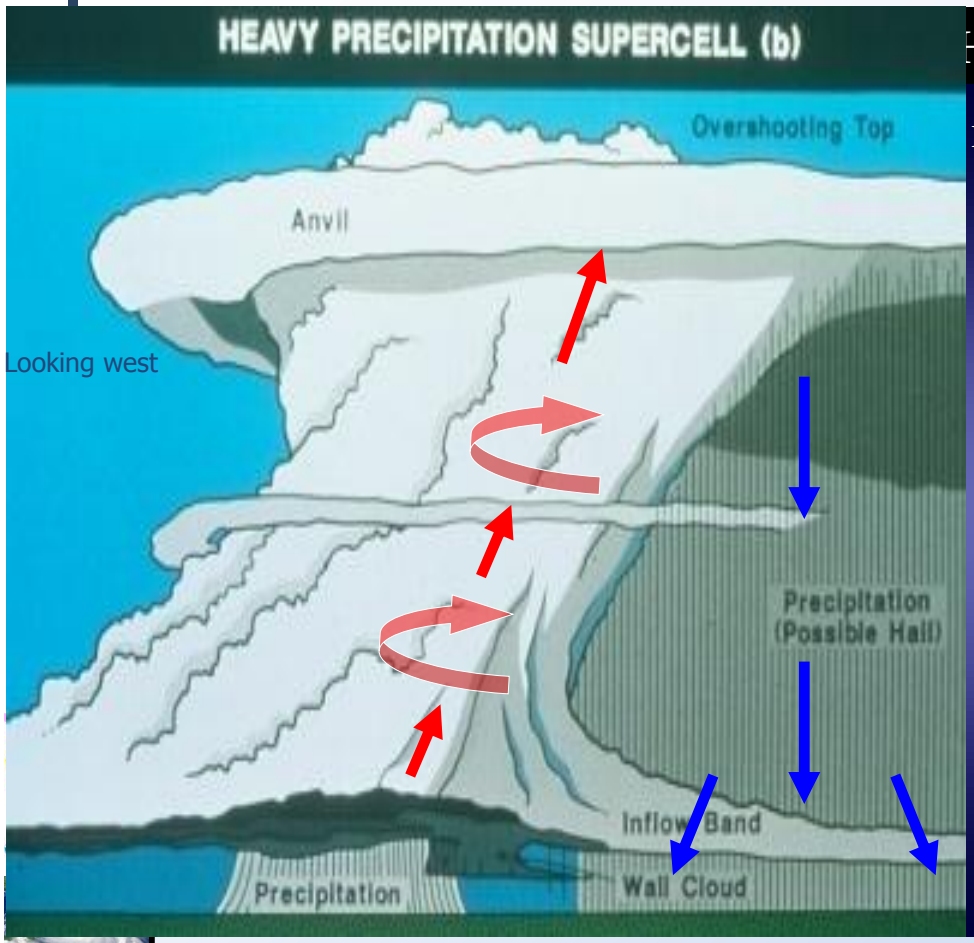
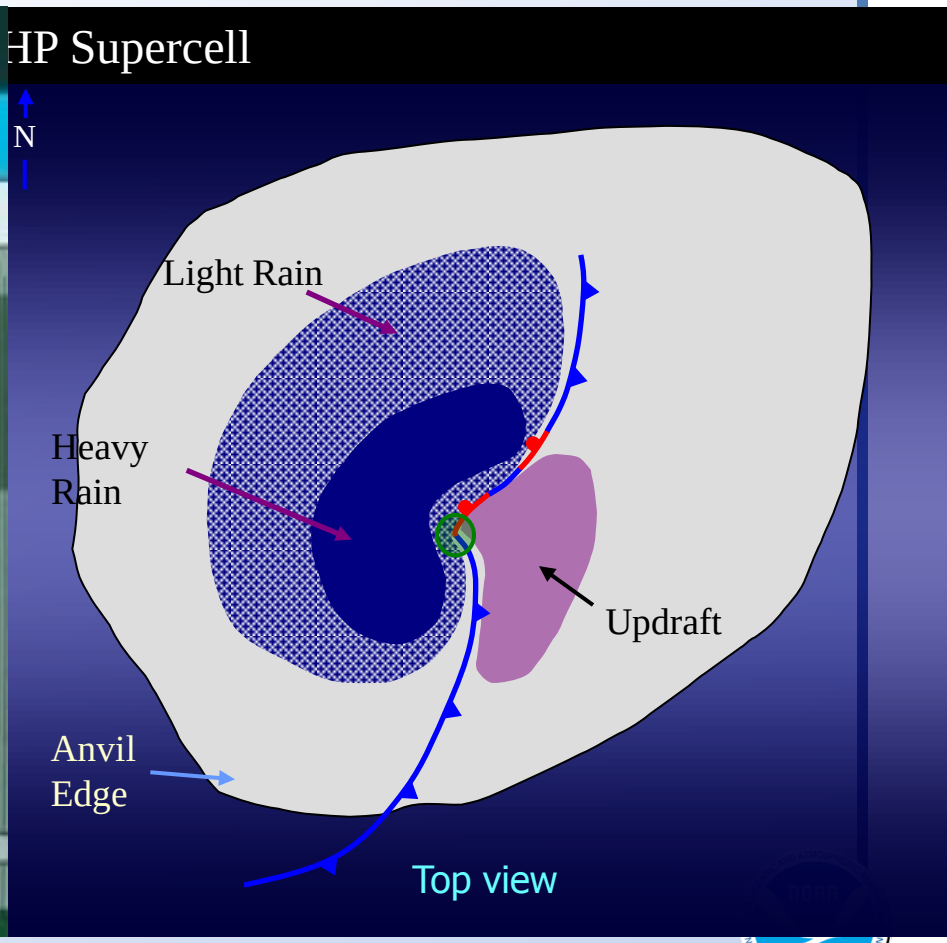
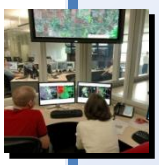




HP Supercell







Generally, there is not a good spot to view this type of storm since it is wrapped by a rain shield.

HP Supercell

Embedded Tornado

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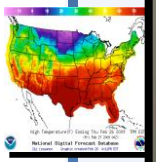
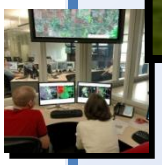
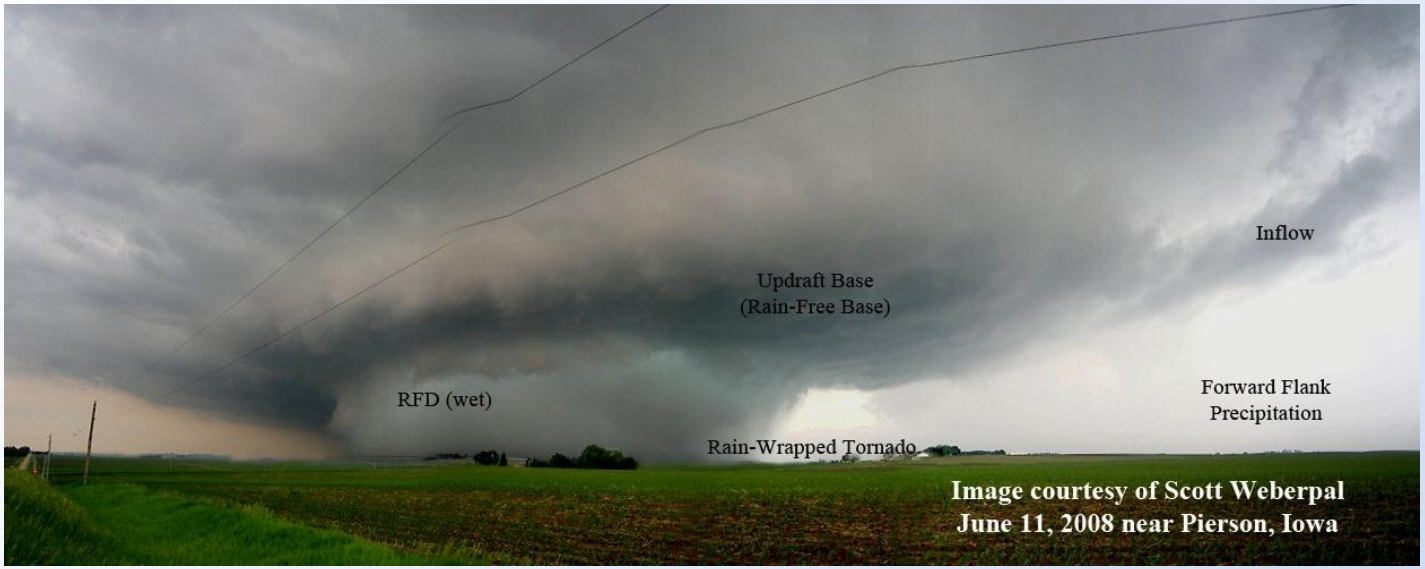




HP Supercell (Hidden Tornado)



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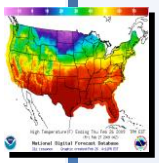
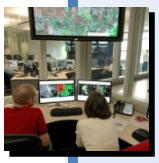
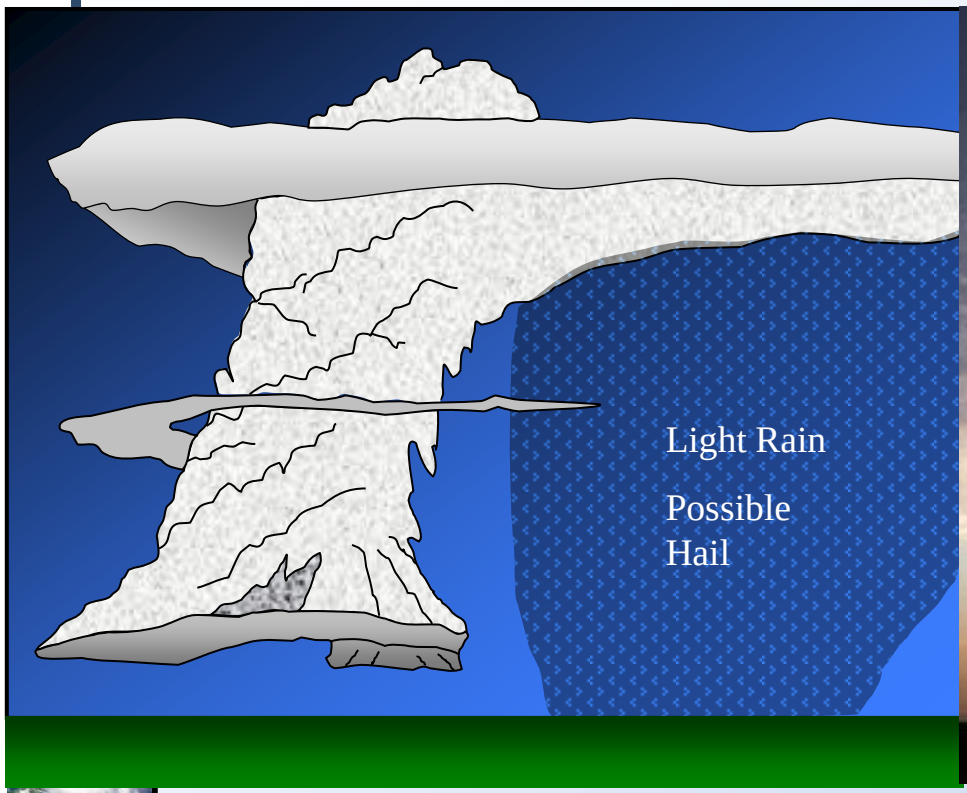
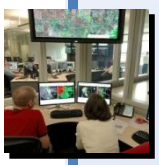




LP Supercell





LP Supercell

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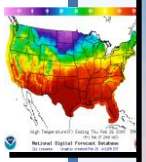
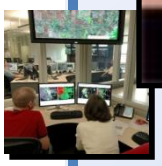
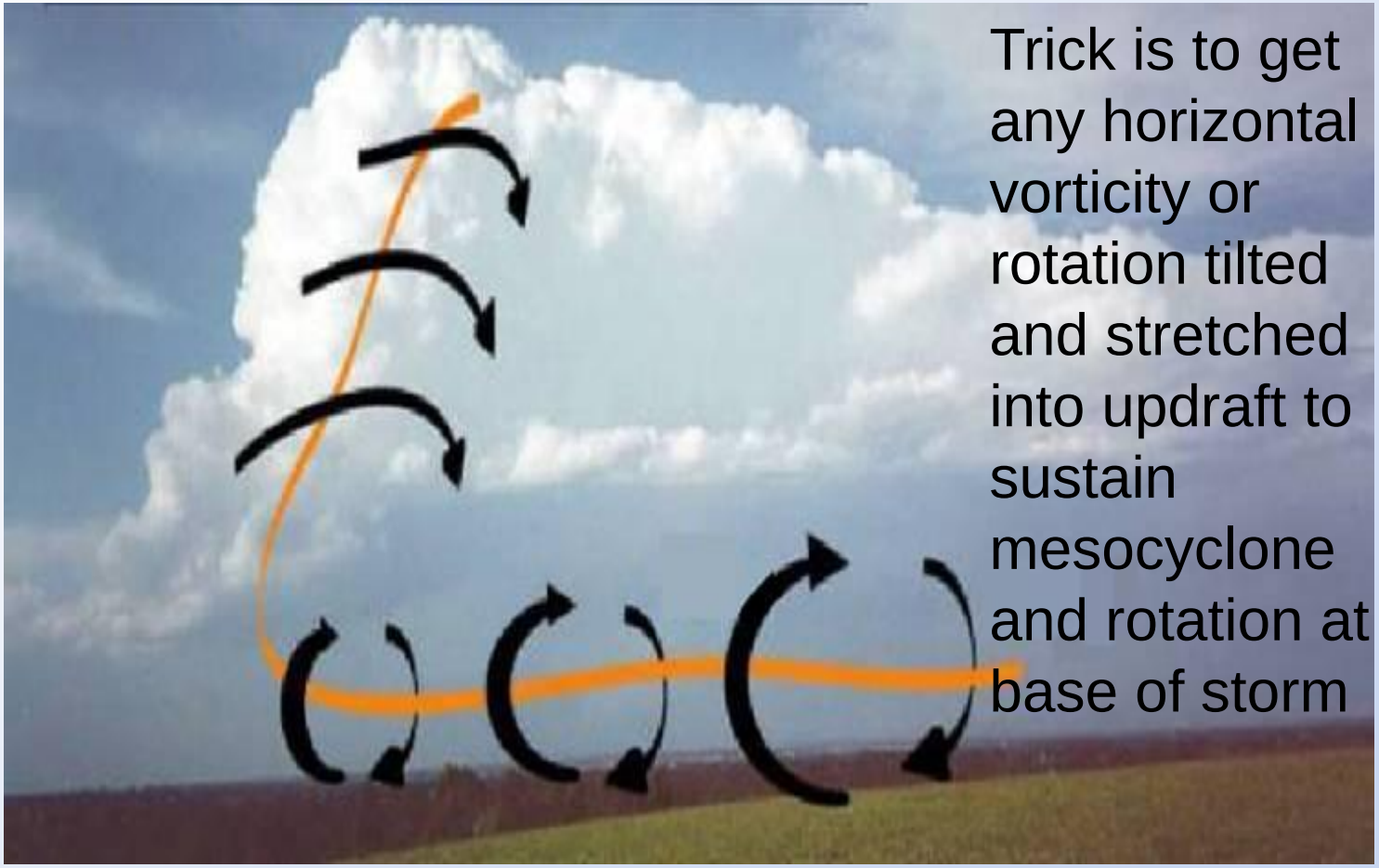




Horizontal Rotation Becoming Veritcal Rotation



Trick is to get any horizontal vorticity or rotation tilted and stretched into updraft to sustain mesocyclone and rotation at base of storm

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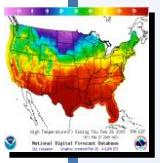
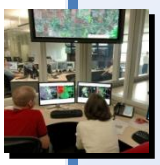
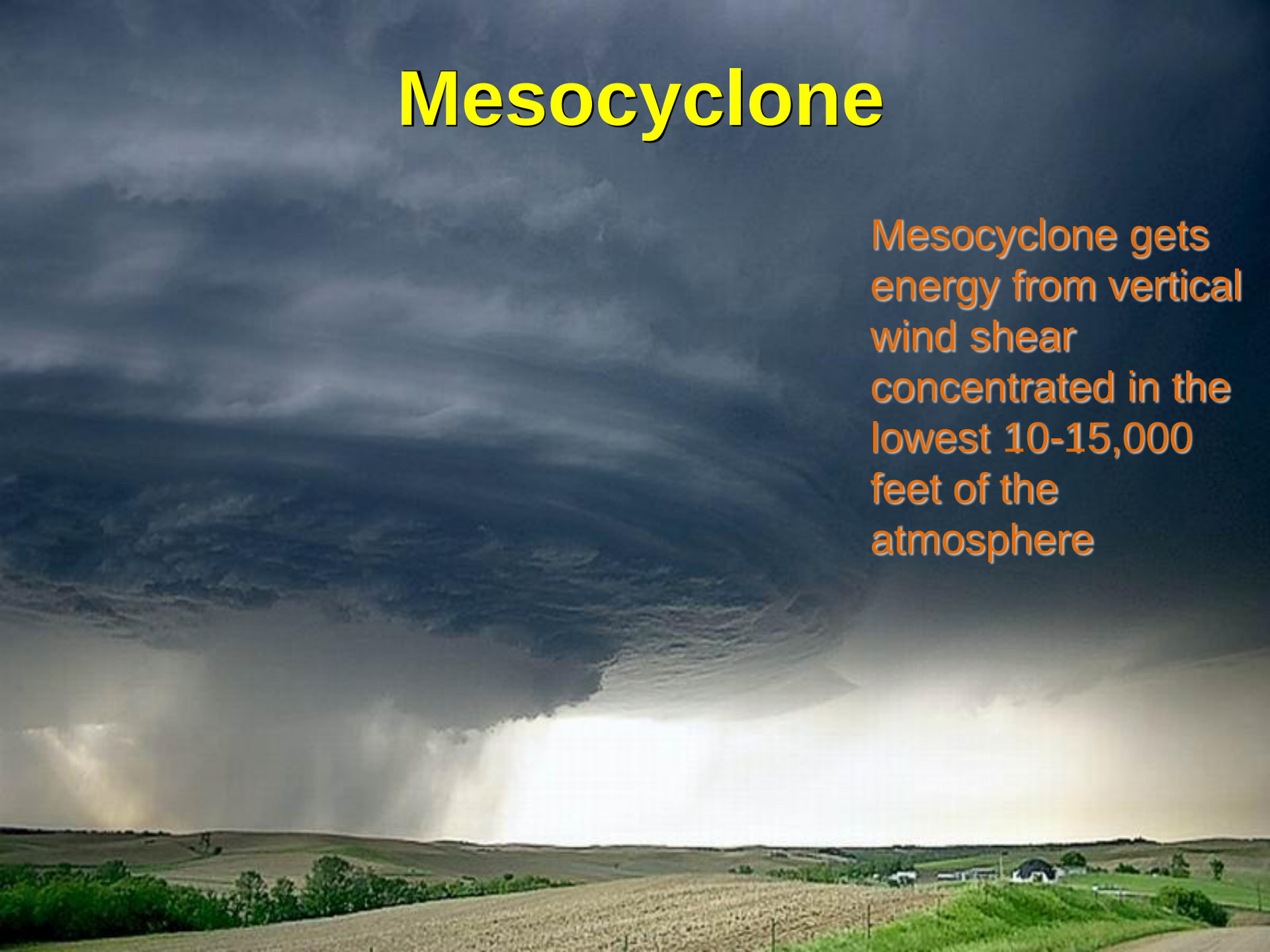




Mesocyclone



Mesocyclone gets energy from vertical wind shear concentrated in the lowest 10-15,000 feet of the atmosphere

Mesocyclone

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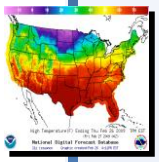
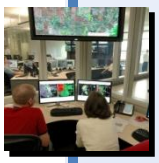
Rotating updraft within the Rain-Free Cloud Base

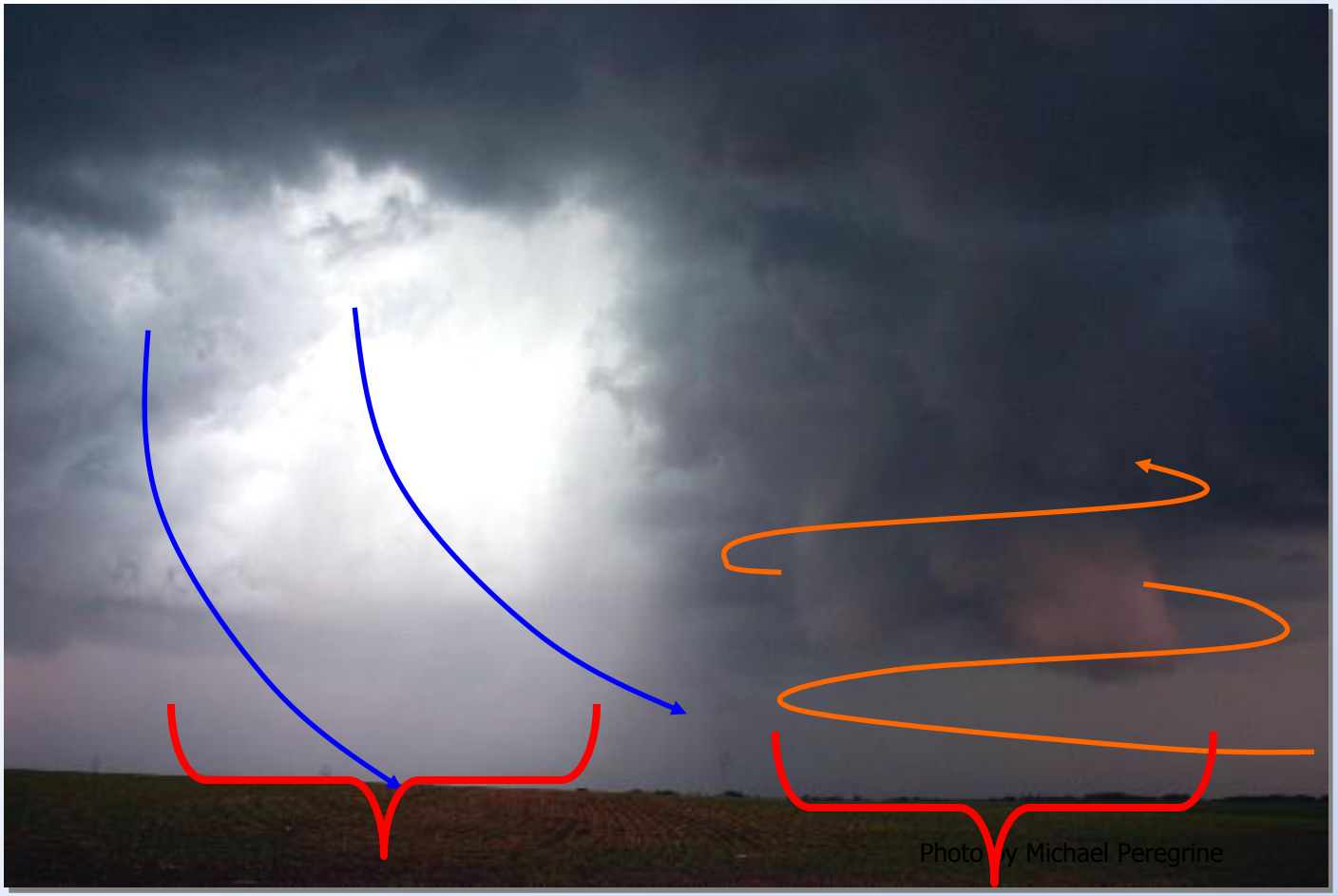
Present with all Supercells!

Research suggests no more than 10% of radar detected mesocyclones are associated with tornadoes





Rear Flank Downdraft



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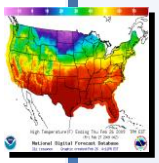

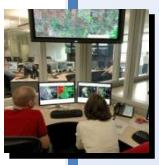

Rear Flank Downdraft

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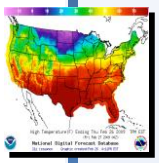

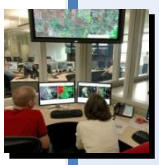

Rear Flank Downdraft Winds

Video

Scott Weberpal
Kinsley, KS
June 15, 2009

No tornado, dust/dirt appears to be lifted to cloud base by RFD

Understanding Tornadogenesis

- **In order to generate a tornado, a storm needs four basic things…**
  - *1. Time – it must persist for an appreciable time (long-lived updraft that doesn't get choked by downdraft). Vertical wind shear (stronger winds aloft) pushes (tilts) the updraft over.*
  - *2. Most of wind shear needs to be concentrated in the lowest 10-thsd feet of the atmosphere – rotation results (mesocyclone).*

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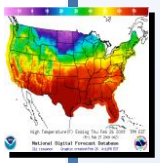

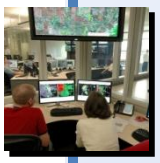

Understanding Tornadogenesis

- **And…**
  - *3. Forward Flank Downdraft (FFD) needs to generate a low-level boundary on it's south side which then allows for local generation of horizontal vorticity (rotation) that can be tilted and stretched vertically in the updraft area of the storm*
  - *4. Rear Flank Downdraft needs to curl around the rotating wall cloud and transfer torque a pre-existing, broad rotation below cloud base, and it needs to have sufficient buoyancy (not too cool) so part of it can take another ride up into the updraft.*

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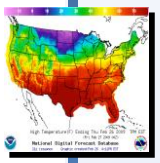

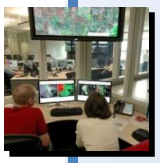

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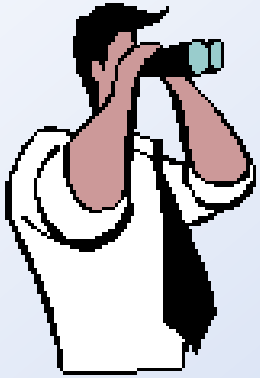
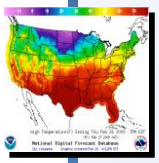
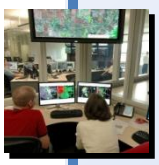
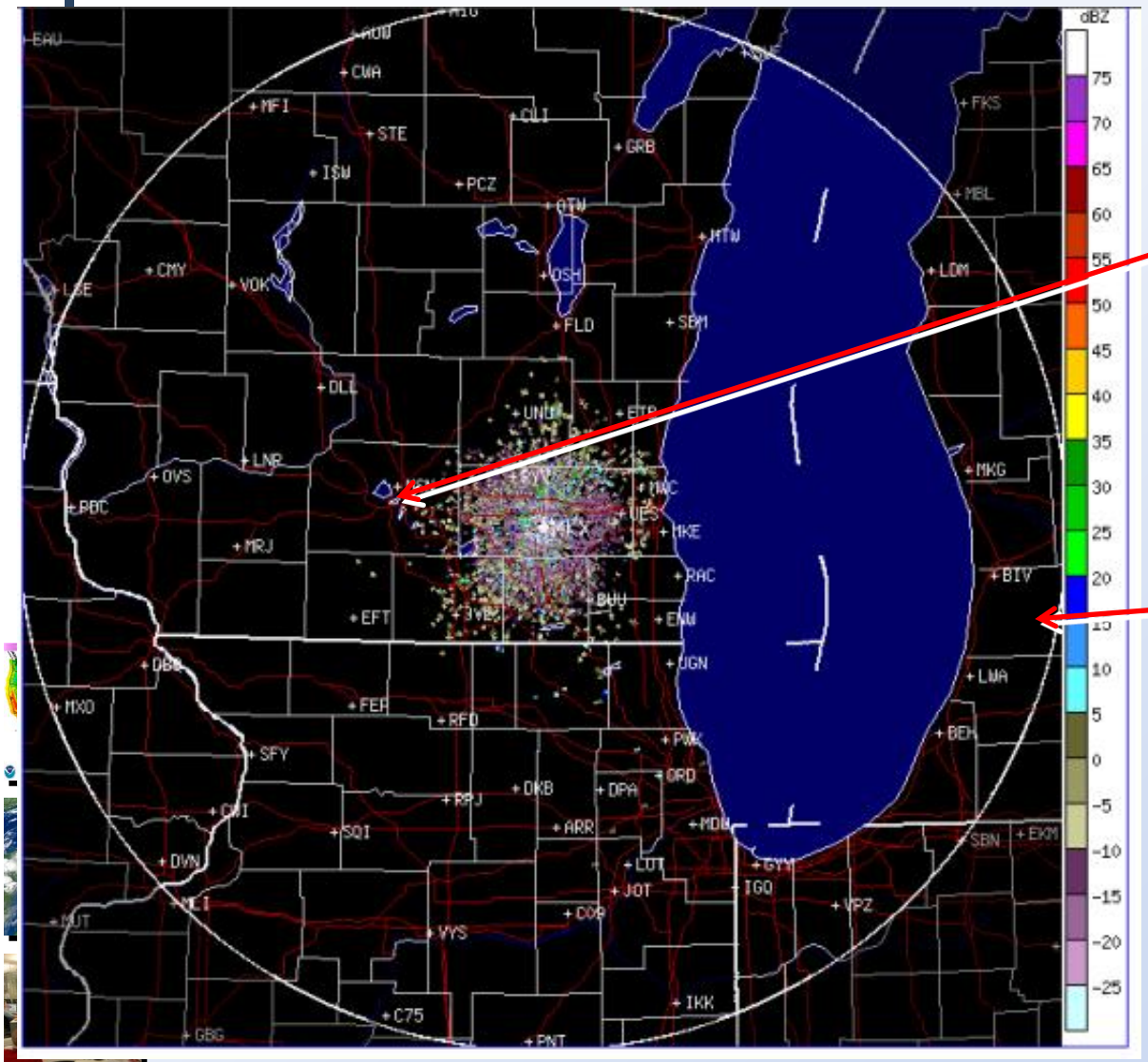
Radar Interpretation







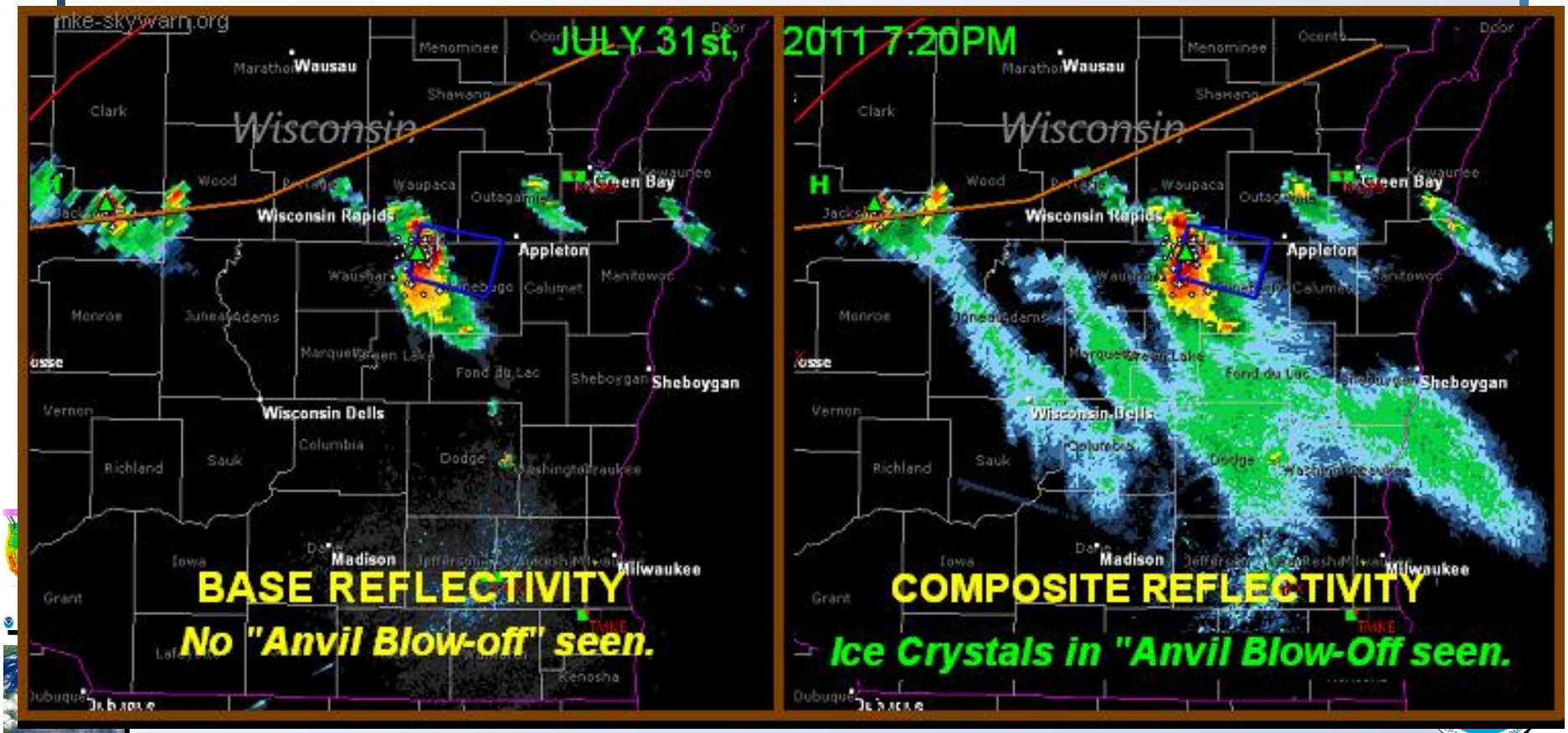
Radar Interpretation

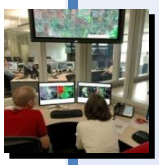


Beam is 5 thsd feet AGL

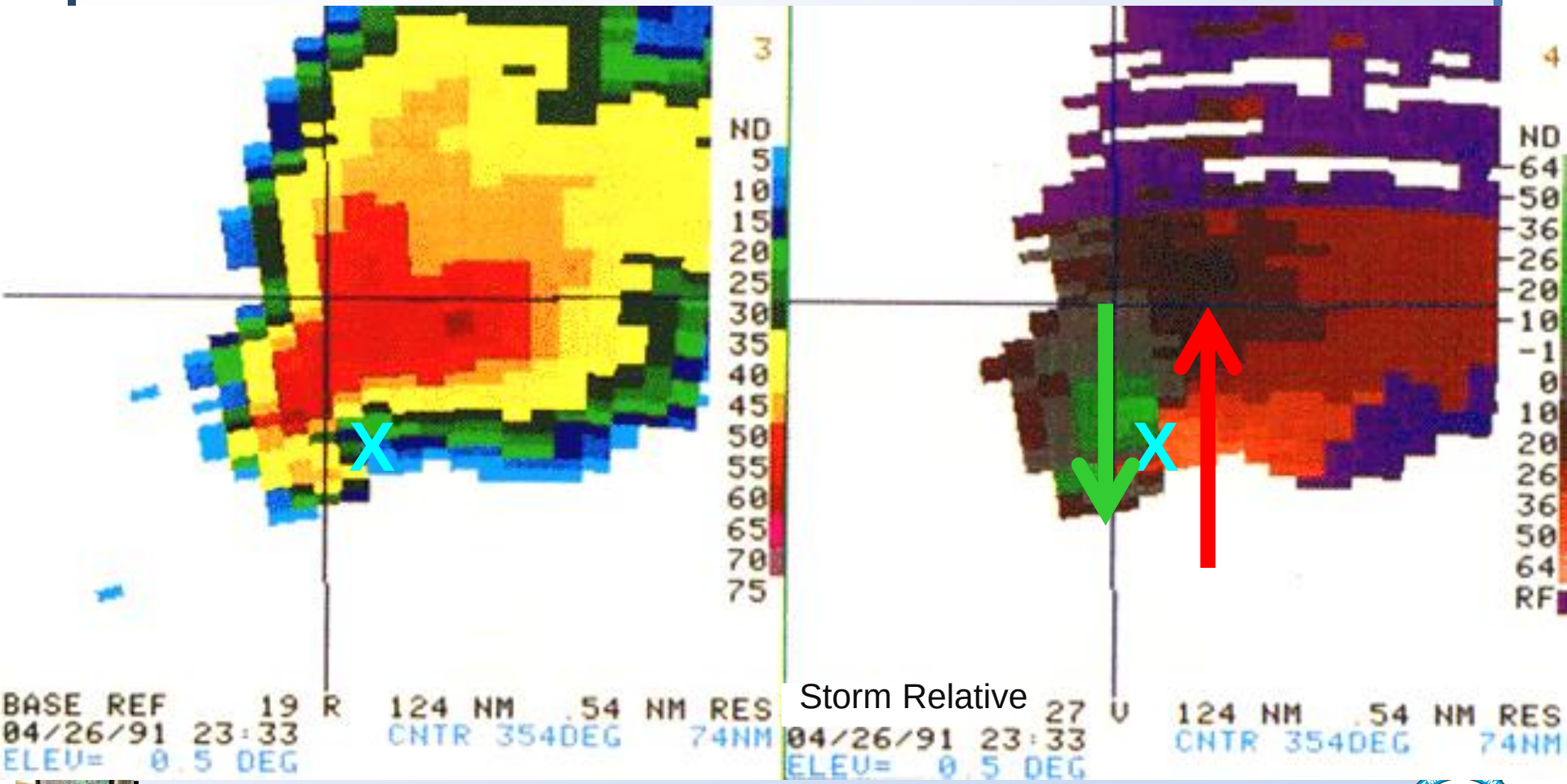
Beam is 17 thsd feet AGL

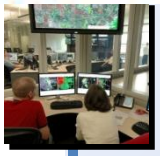
Base Versus Composite





Classic Supercell





Radar site

Radar site

Storm Splitting

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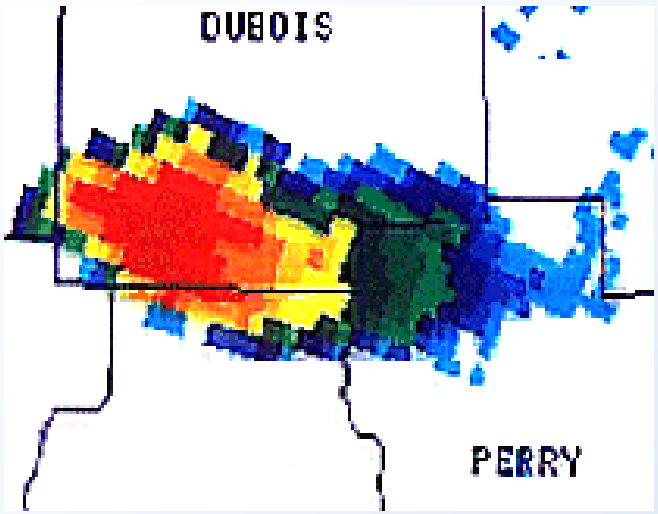
1



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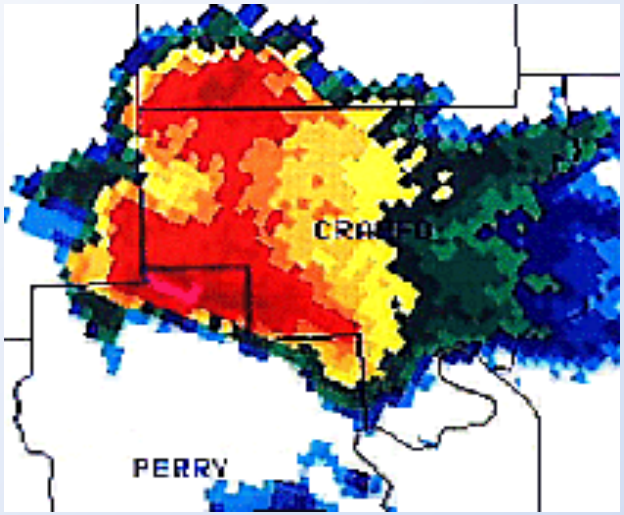

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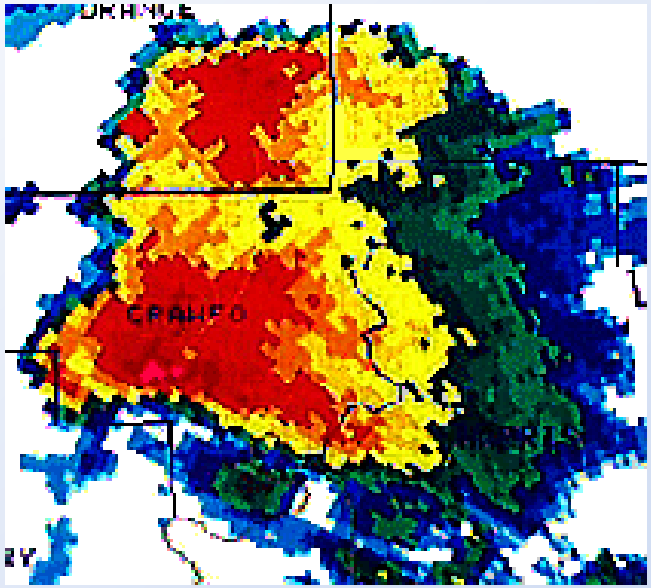

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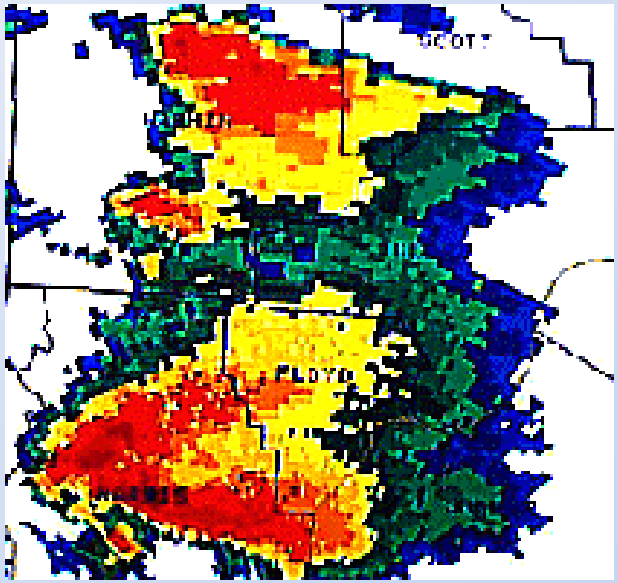
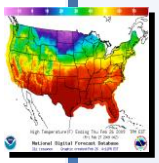
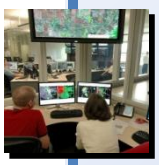
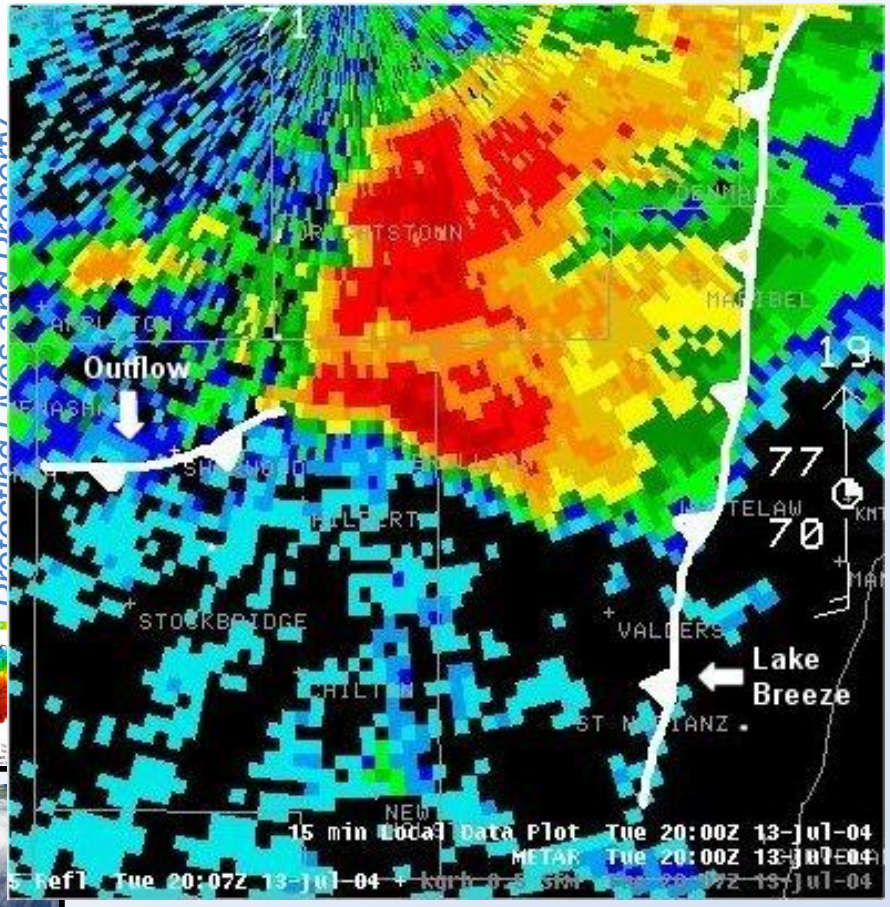
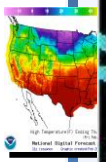


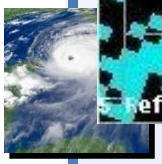


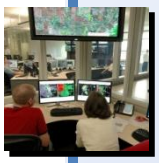


Cell Merger









Line Echo Wave Pattern

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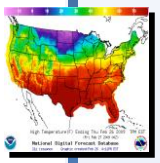
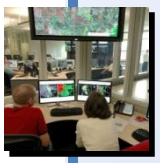
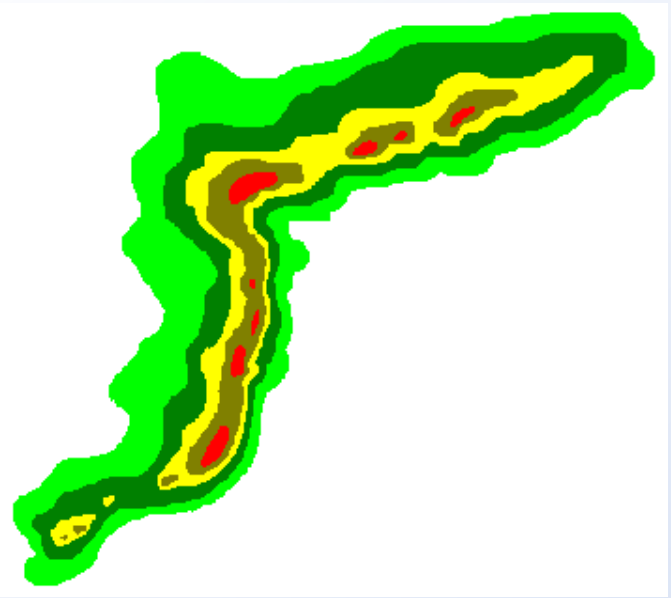
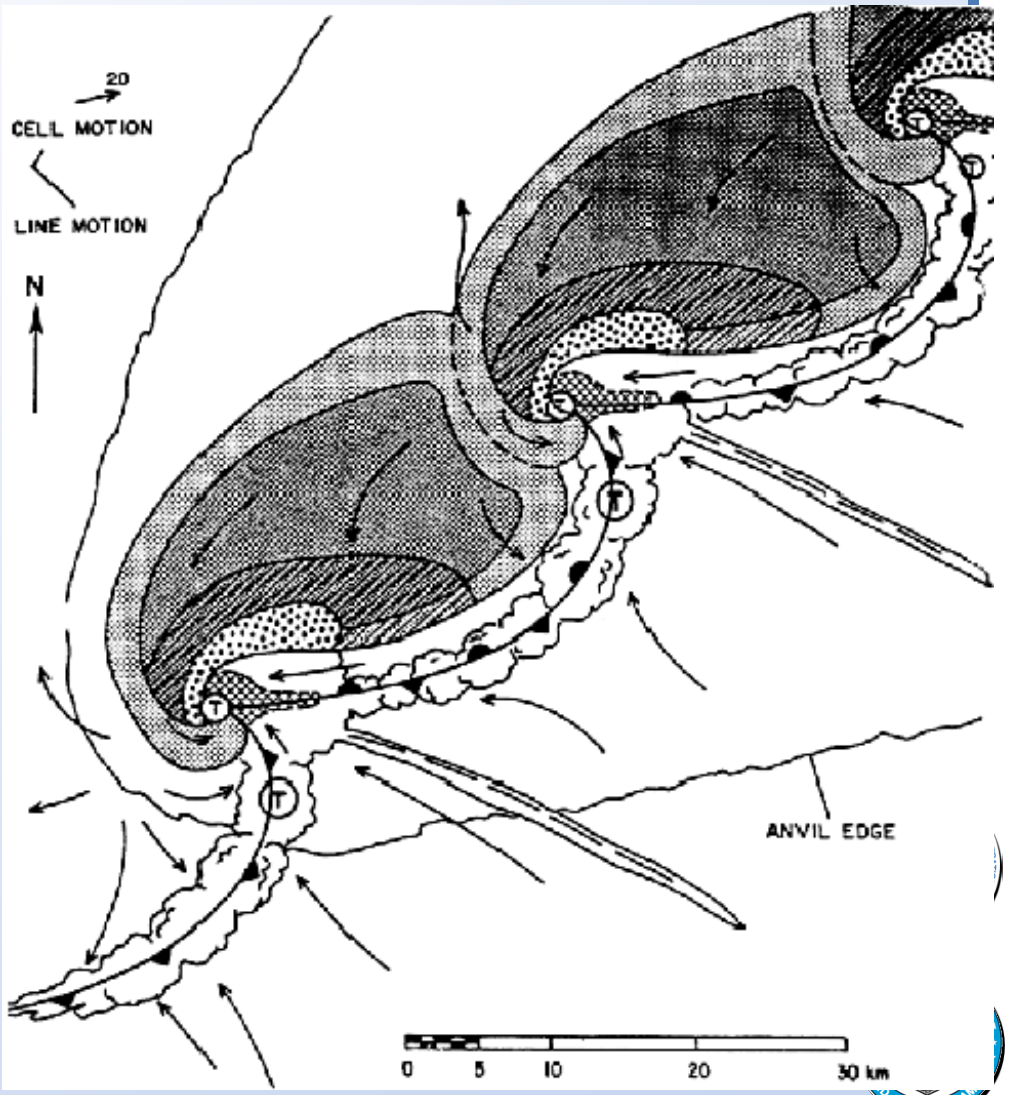


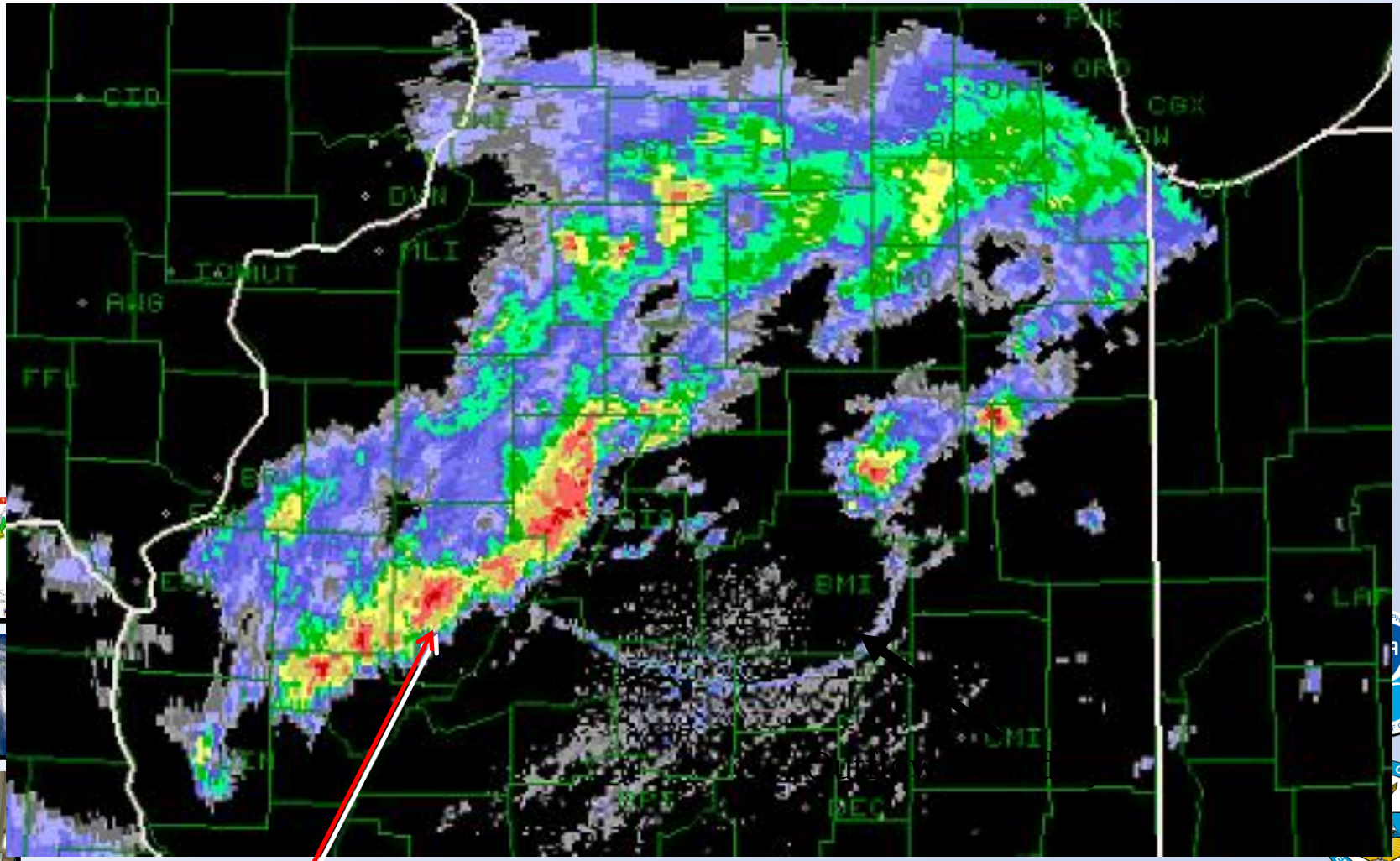




Meso Low



Outflow Boundaries



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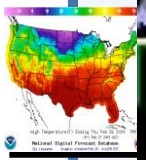
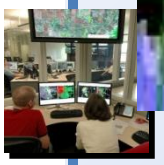
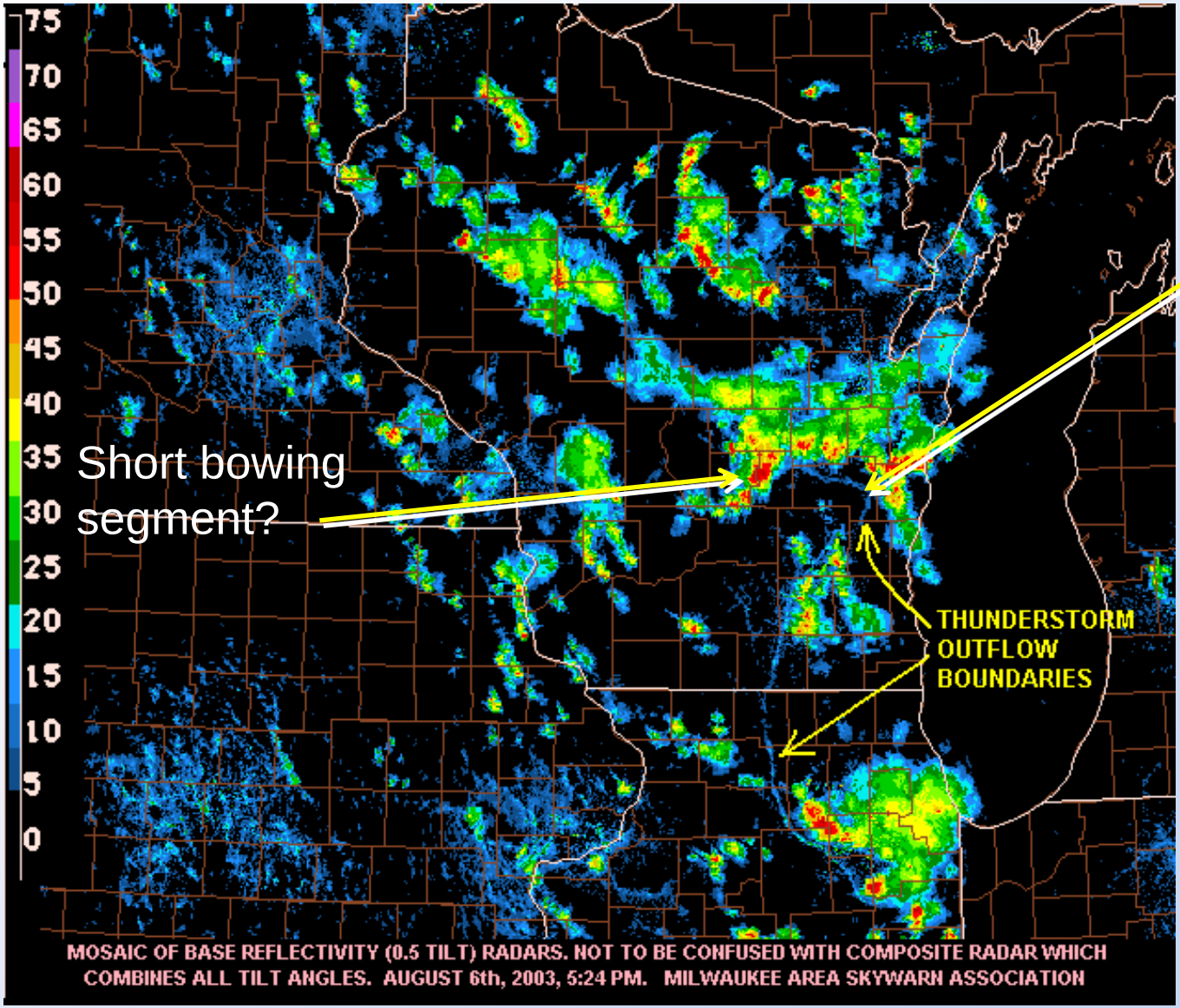




Outflow Boundaries



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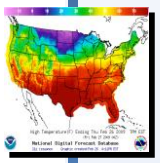

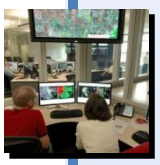

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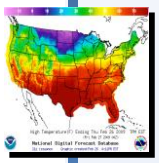

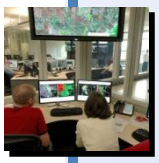

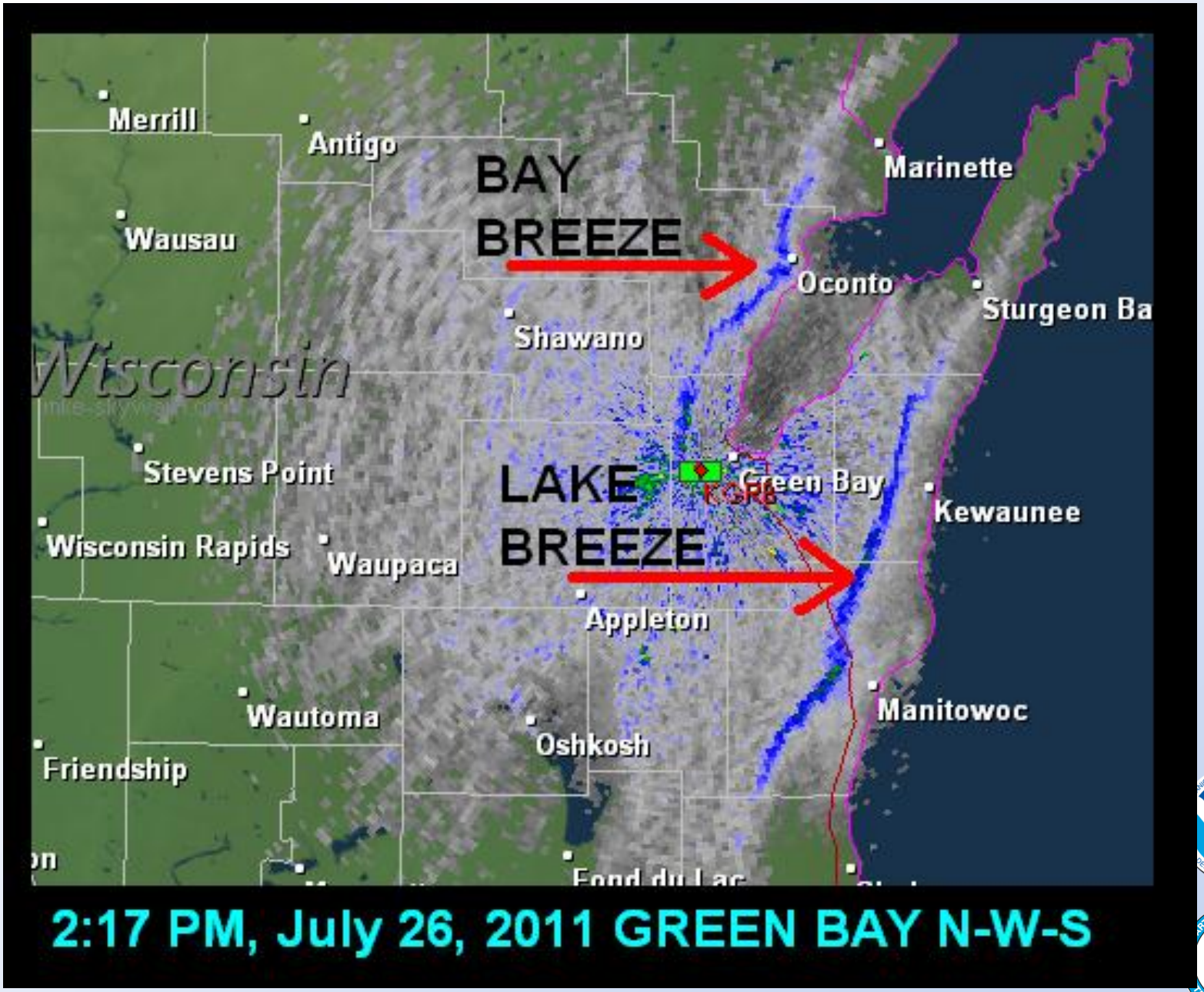

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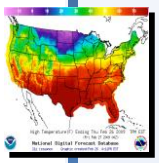

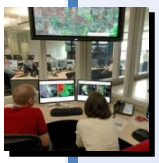

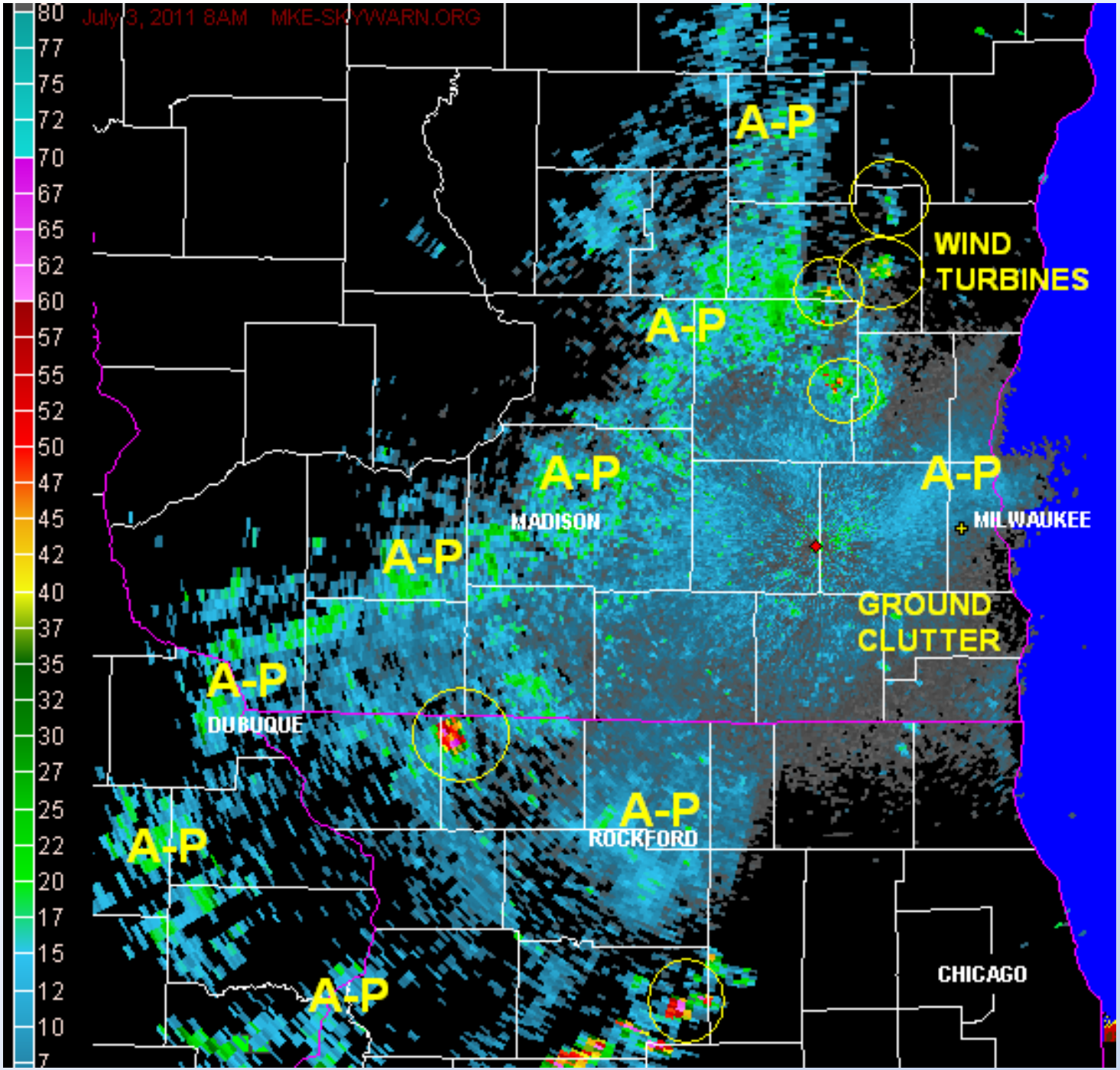

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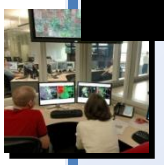
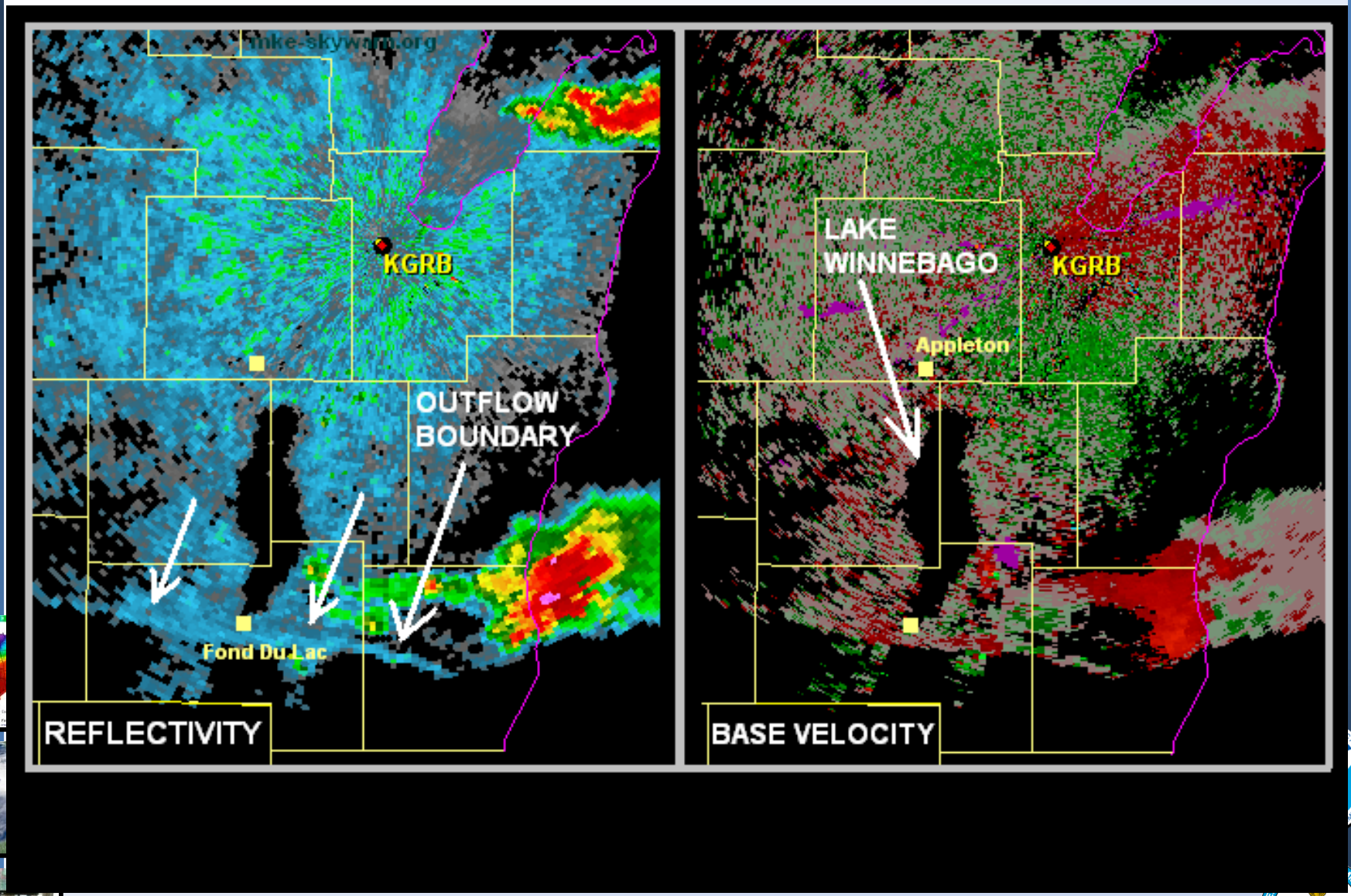
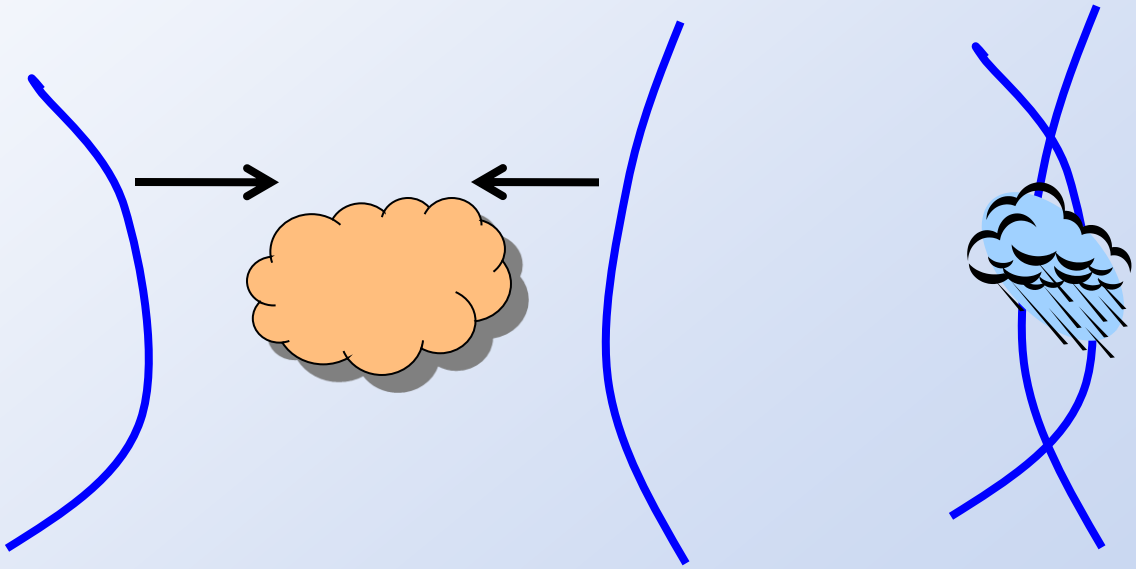




Storm Intensification

* Watch for storm buildups along outflow boundaries when they plow into humid air.
* If two outflow boundaries approach from different directions, when they intersect and collide watch for new storms or intensification of existing storms in the region of the collision.



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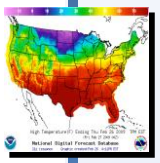

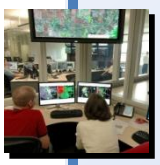

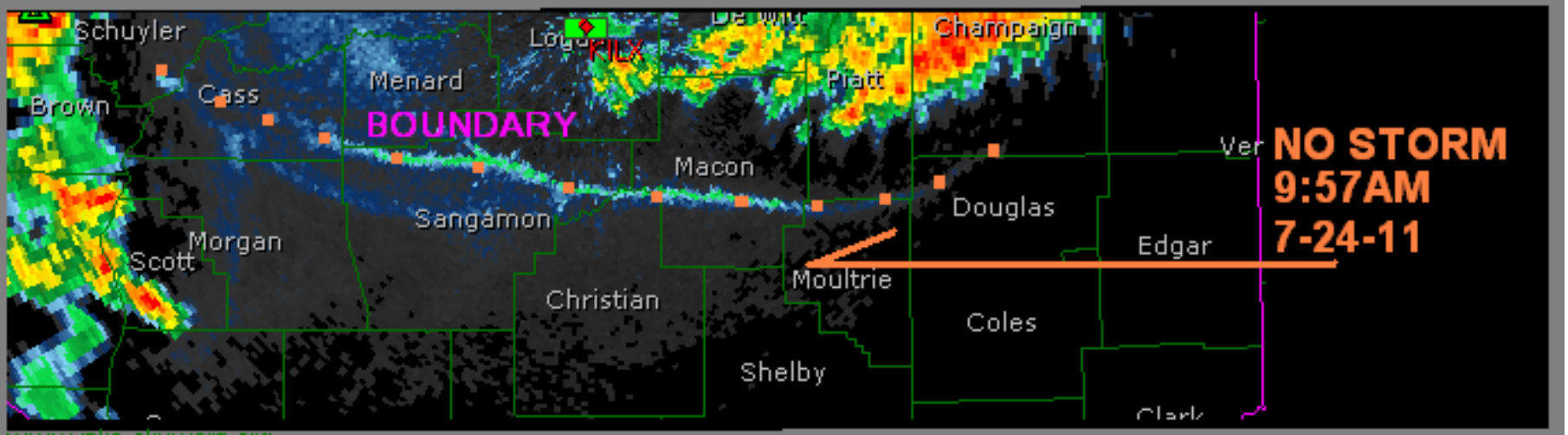

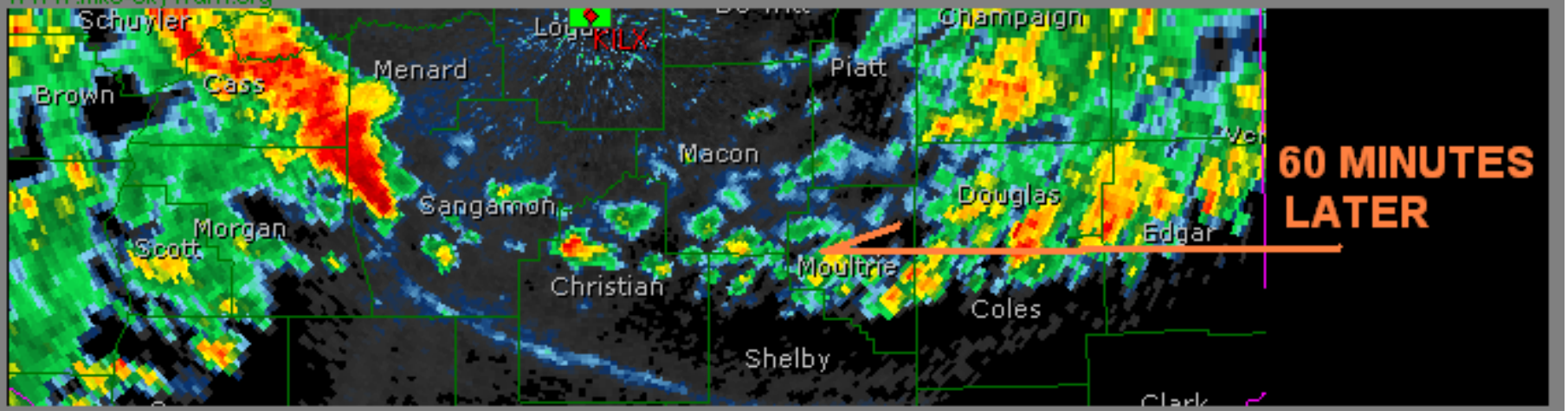

STRONG OUTFLOW BOUNDARY CREATED NEW STORMS WITHIN 60 MINUTES OVER CENTRAL ILLINOIS COUNTIES.

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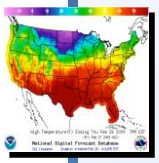

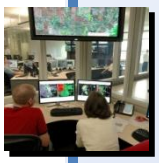

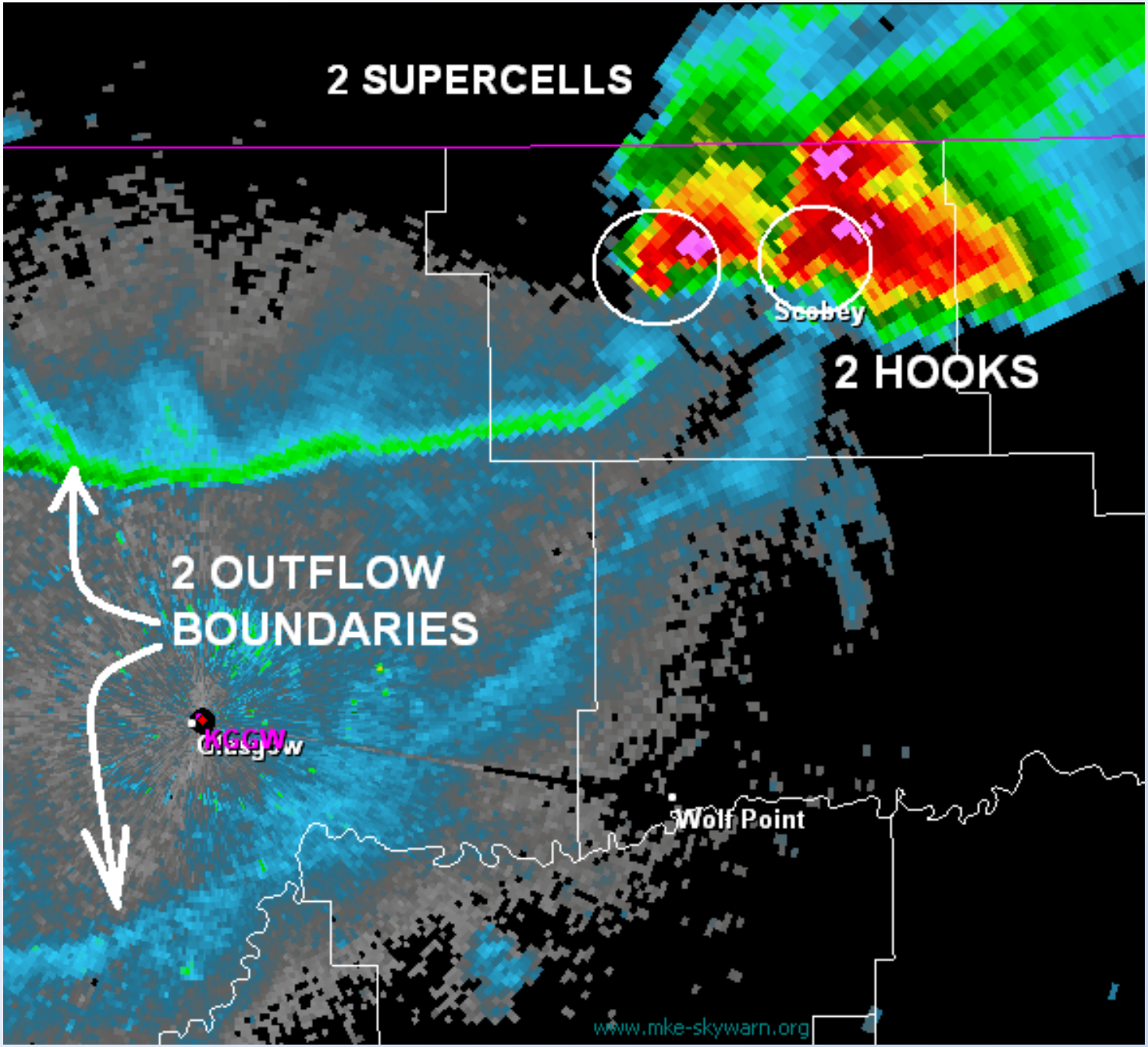

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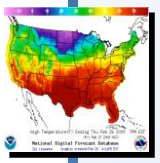

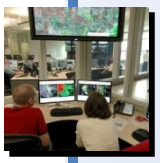

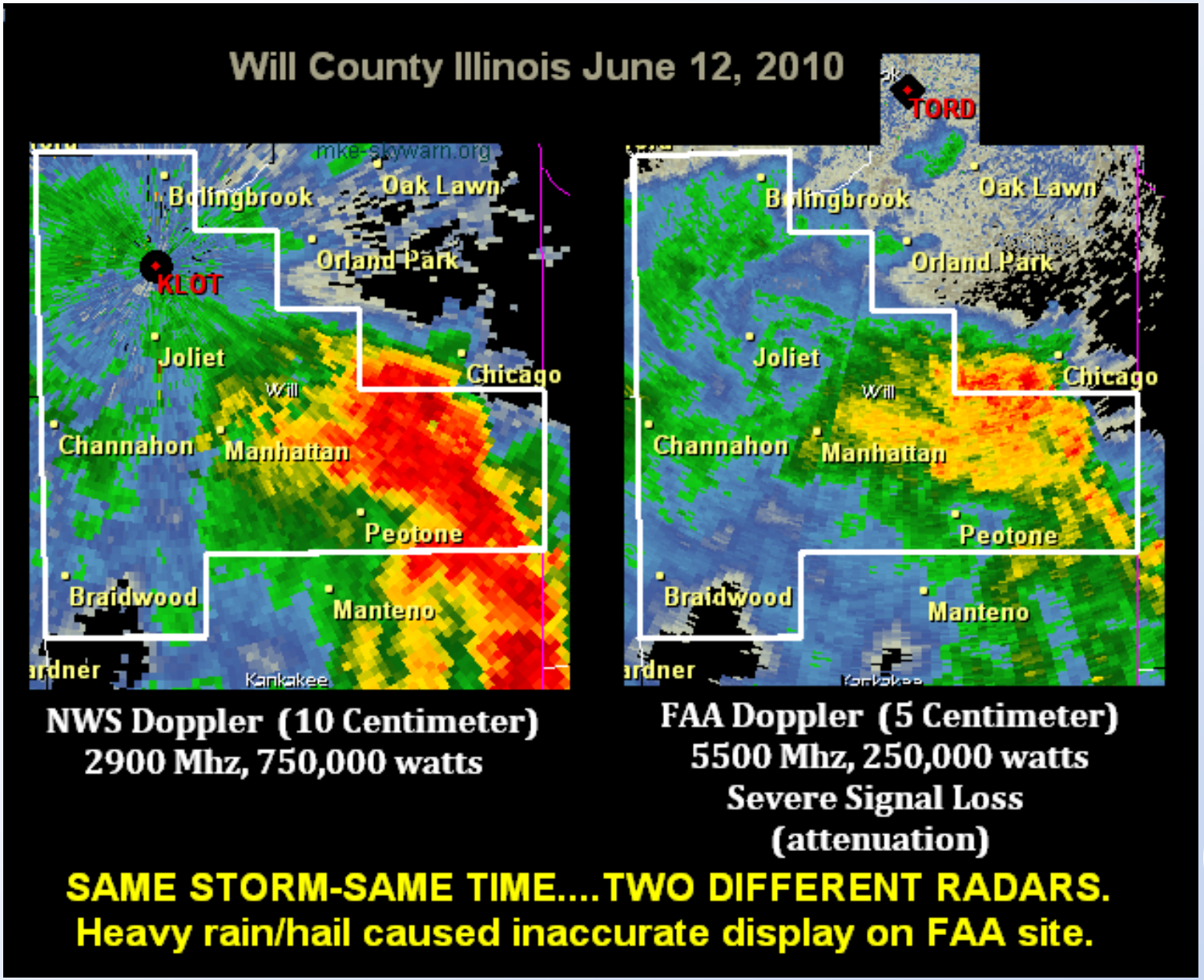

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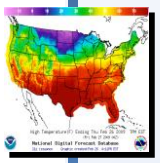

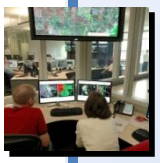

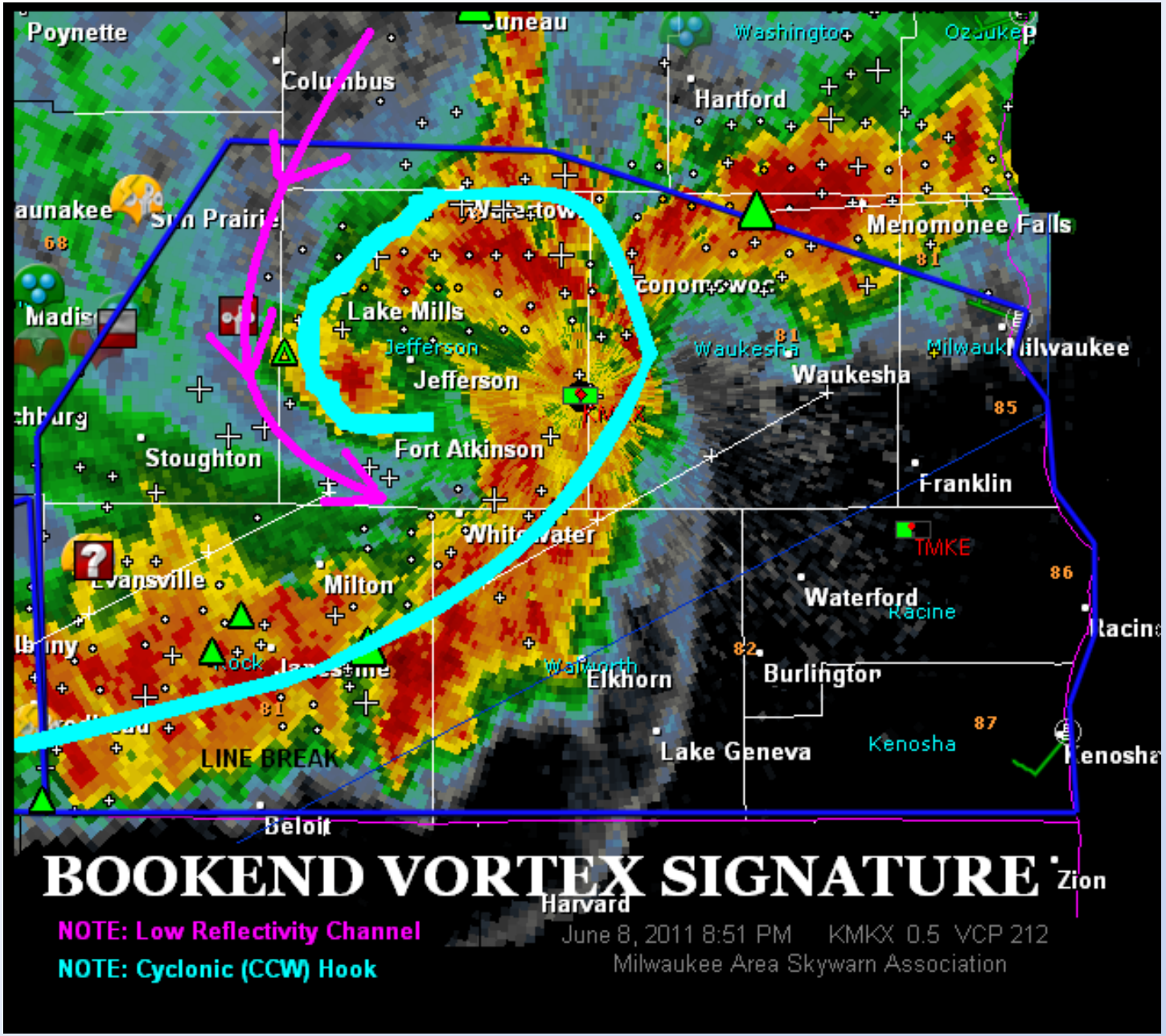

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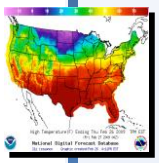

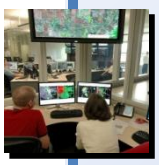

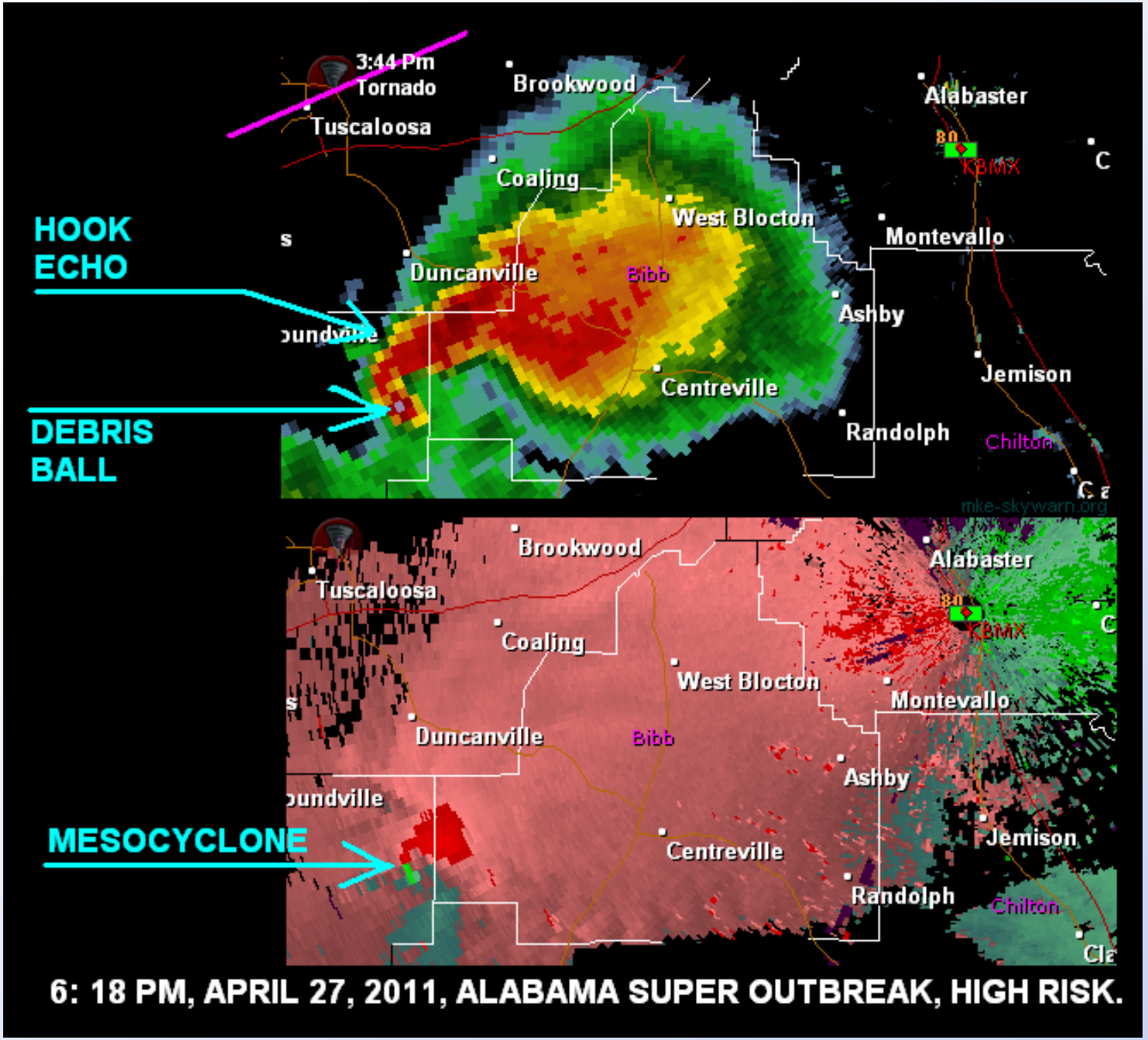

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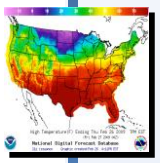

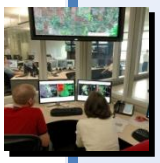

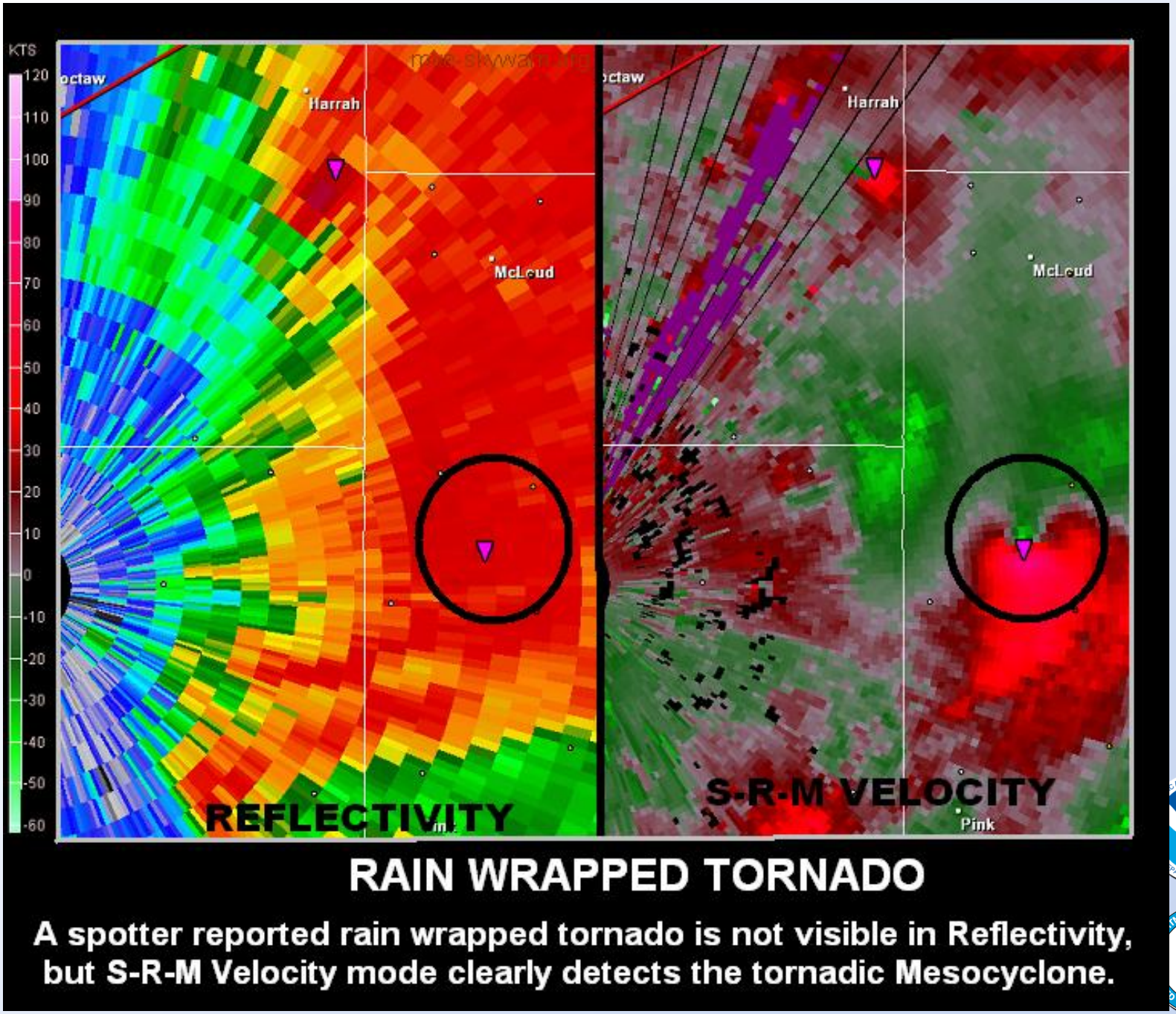

RAIN WRAPPED TORNADO

A spotter reported rain wrapped tornado is not visible in Reflectivity, but S-R-M Velocity mode clearly detects the tornadic Mesocyclone.

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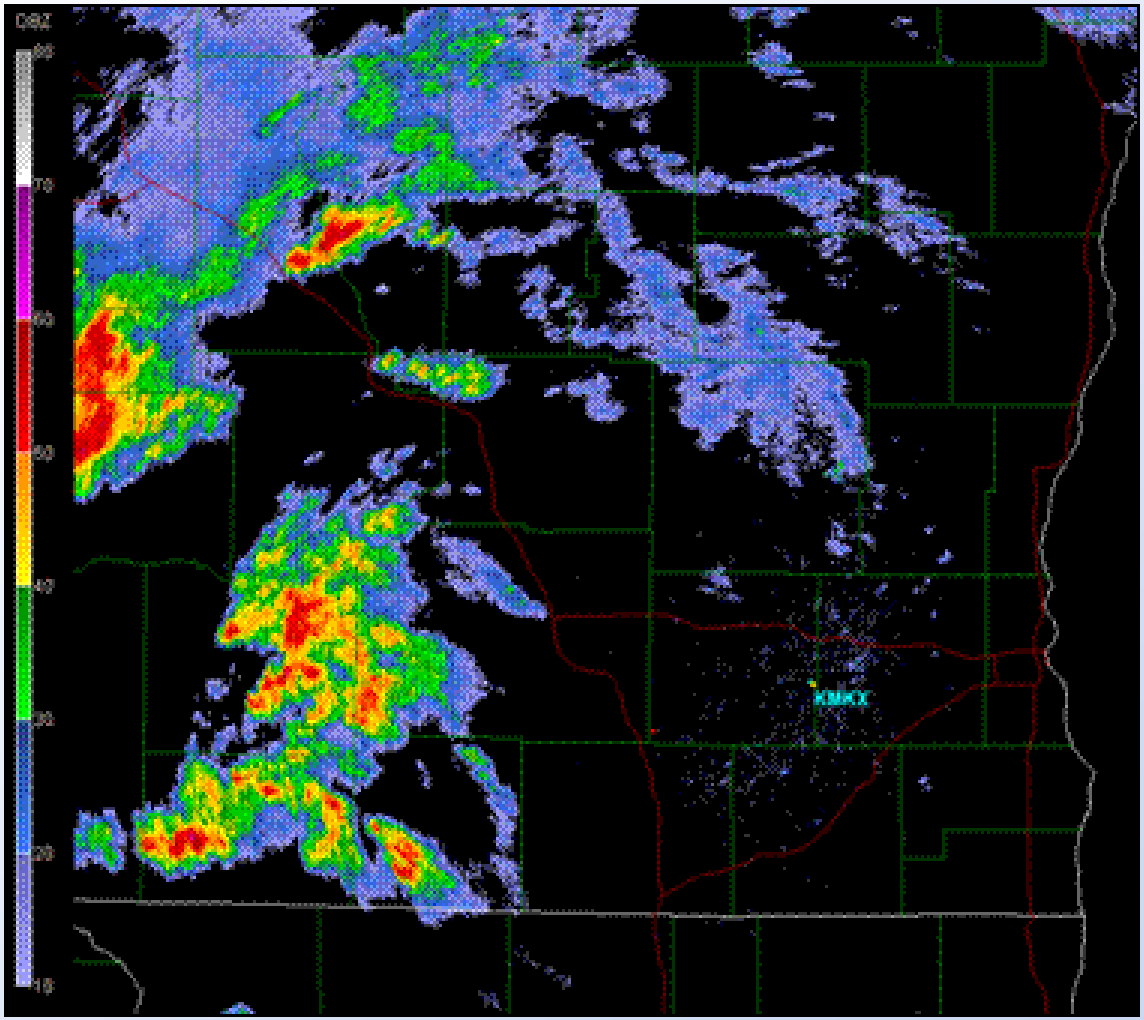
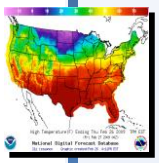
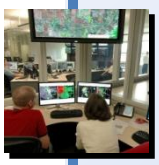
June 21, 2010







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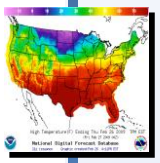
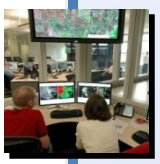
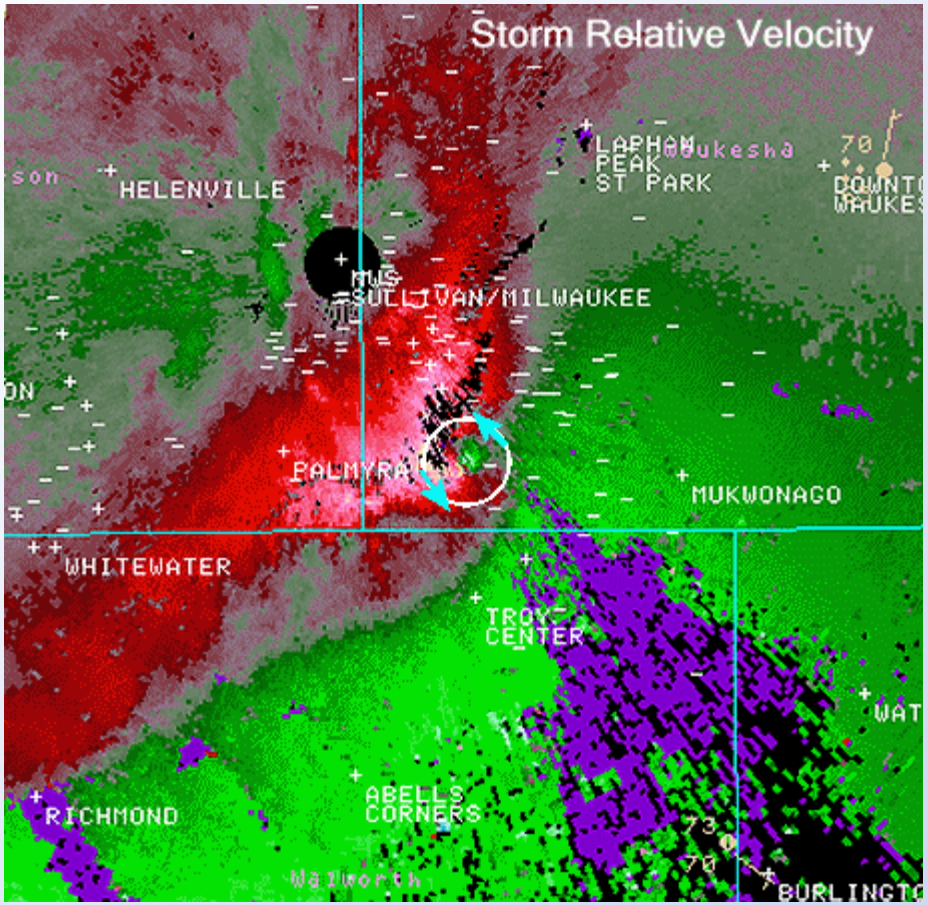




June 21, 2010



June 21, 2010

Eagle, WI Damage

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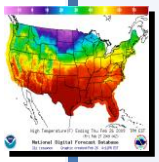

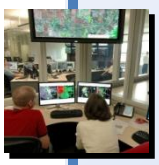

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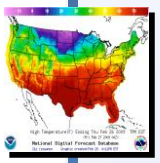
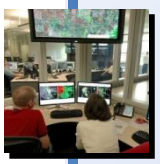
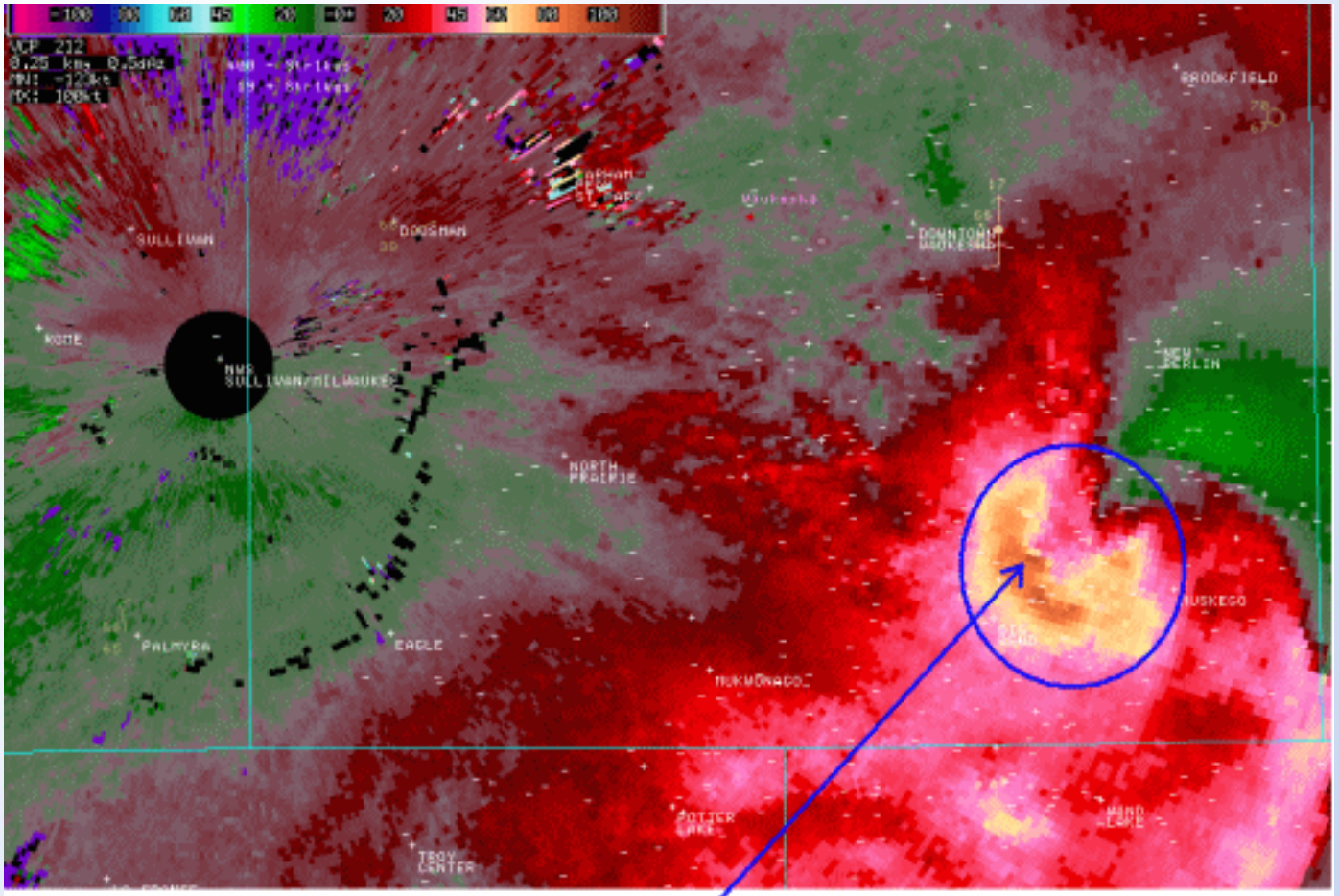


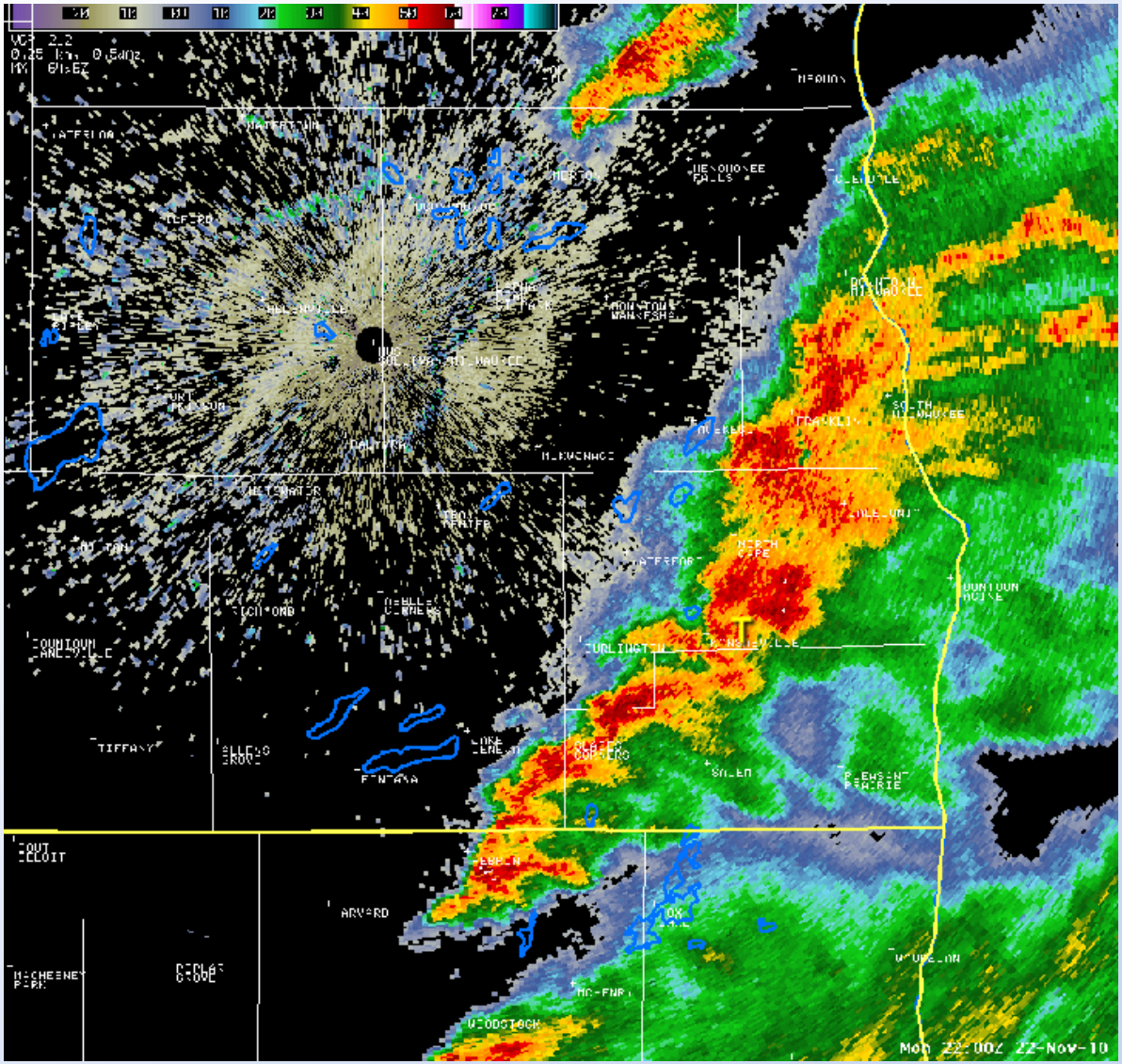


June 21, 2010



Downburst in Big Bend & Muskego area...up to 107 mph winds indicated on Doppler Radar 943pm

November 22, 2010



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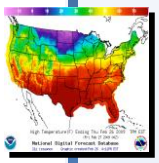

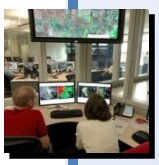

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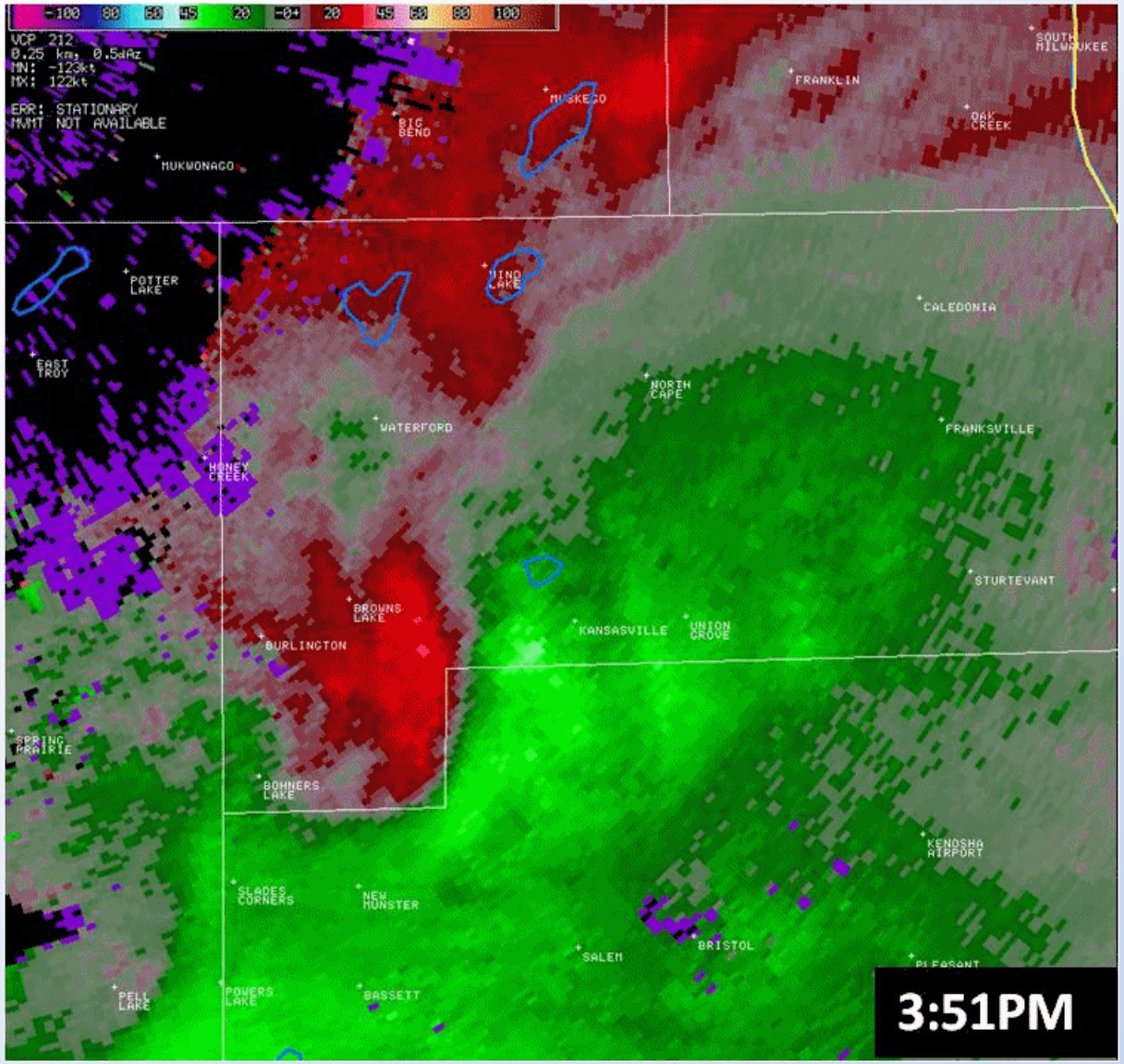
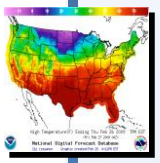
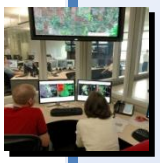
November 22, 2010







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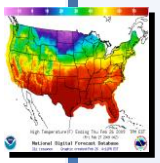

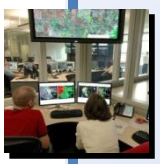

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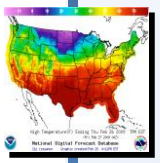

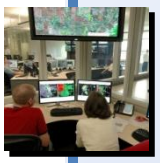

HOW WOULD YOU DESCRIBE THIS DAMAGE WHEN SUBMITTING A STORM REPORT??

End of Class!

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